“PROSPECTIVE AND RETROSPECTIVE ANALYSIS OF POSTERIOR CRUCIATE LIGAMENT INJURIES AND ITS MANAGEMENT ”

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CERTIFICATE

This is to certify that this dissertation **"PROSPECTIVE AND RETROSPECTIVE ANALYSIS OF POSTERIOR CRUCIATE LIGAMENT INJURIES AND ITS MANAGEMENT"** is a bonafide record of work done by **DR.R.RAJKUMAR,** during the period of his Post graduate study from May 2016 to May 2019 under guidance and supervision in the INSTITUTE OF ORTHOPAEDICS AND TRAUMATOLOGY, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai-600003, in partial fulfilment of the requirement for **M.S.ORTHOPAEDIC SURGERY** degree Examination of The Tamilnadu Dr. M.G.R. Medical University to be held in April 2019.

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DECLARATION

I declare that the dissertation entitled **"PROSPECTIVE AND RETROSPECTIVE ANALYSIS OF POSTERIOR CRUCIATE LIGAMENT INJURIES AND ITS MANAGEMENT"** submitted by me for the degree of M.S ORTHO is the record work carried out by me during the period of September2016 to September 2018 under the guidance of Prof.N.DEEN MUHAMMAD ISMAIL, M.S.Ortho., D.Ortho., Director , Professor of Orthopaedics, Institute of Orthopaedics and traumatology, Madras Medical College, Chennai. This dissertation is submitted to the Tamilnadu Dr.M.G.R. Medical University, Chennai, in partial fulfilment of the University regulations for the award of degree of M.S.ORTHOPAEDICS (BRANCH-II) examination to be held in April 2019.

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CONTENTS

INTRODUCTION

Ligamentous injuries of the knee are more common in this era of urbanization. Posterior Cruciate Ligament [PCL] injuries are often overlooked than Anterior Cruciate Ligament [ACL] injuries.

PCL injuries constitute 3 to 23% of knee injuries but the true incidence remains unrevealed because they often go unnoticed in the emergency setting. Now there is an increasing incidence of PCL injuries because of increase in automobiles and involvement in competitive sports.

The management of PCL injuries remains a controversy among orthopaedic surgeons. The available literature on PCL injuries are mostly retrospective that includes both isolated & combined ligamentous injuries of the knee. Lack of randomized prospective studies with conclusive evidence makes it difficult to arrive onto a conclusion regarding management of PCL injuries.

The infrequent occurrence of PCL injuries limited the understanding of the natural history of this injury. Now PCL has shared the researchers' attention in par with other ligamentous injuries. New studies have figured out the anatomy and biomechanics of PCL leading to increased interest in research & treatment.

AIM OF THE STUDY

The aim of the study is to analyze the outcome in patients with posterior cruciate ligament injuries and the various factors influencing the outcome in such patients.

REVIEW OF LITERATURE

William C McMaster[55] 1975 - Published case reports of isolated posterior cruciate ligament injury. The mechanism of injury was a direct blow to the anterior aspect of the knee in a flexed position. The radiographic evidence was avulsion of the posterior tibia margin. He surgically fixed the avulsion fracture and the functional outcome after 3 months was satisfactory with ligamentous stability.

Bianchi et al.[3] 1981 - Surgical reconstruction of acute tears of posterior cruciate ligament yield satisfactory functional results.

Cross et al.[13] 1981 - Functional results in patients with Posterior cruciate ligament tear depends on good quadriceps tone.

Hughston et al. 1981 - Reconstruction of PCL using medial gastrocnemius tendon.

Loos et al.[33] 1981 - Acute posterior cruciate ligament injuries are often missed. Hence a thorough clinical examination under anesthesia and arthroscopy can prevent unsuspected diagnosis.

Dandy et al.[14] 1982 - Functional outcome in unrepaired tear of PCL is independent of the degree of laxity.

Parolie et al.[39] 1986 - Showed satisfactory long term results by conservative management of isolated PCL injuries in athletic individuals.

Fowler et al.[19] 1987 - Conservative management in cases with isolated PCL injuries can be preferred over reconstruction of the ligament.

Tibone et al.[51] 1988 - Suggested no advantage/ disadvantage of PCL reconstruction and emphasized on rehabilitation of gastrocnemius-soleus complex in patients with PCL injuries.

Van Dommelen et al.[53] 1989 - Emphasized the diagnostic importance of anatomy of PCL and treatment of the ligamentous injuries.

Chiu et al.[12] 1991 - In PCL avulsion injuries with displacement, internal fixation should be preferred.

Keller et al.[27] 1993 - In isolated PCL injuries, non-operative treatment maintain muscle strength but degenerative changes increase as time progress.

Lipscomb et al.[31] 1993 - Long term study reveals that reconstruction for isolated PCL tear does not completely limit posterior instability.

Rubinstein et al.[45] 1993 - Grade 1 & 2 PCL tears can be managed non-operatively. Grade 3 tears need acute reconstruction/ repair.

Schenck et al.[47] 1993 - Advised PCL reconstruction in dislocated knees with multi ligamentous damage.

Harner et al.[21] 1994 - Elucidated the ligament morphology & biomechanics of the human PCL complex.

Littlejohn et al.[32] 1995 - Arthroscopic repair of PCL avulsion using cannulated screws, a case report.

Seitz et al.[49] 1996 - PCL avulsion fixed with screw / K-wire yield excellent results. Functional rehabilitation immediately following internal fixation leads to better results. Early rehabilitation is possible in cases where screw fixation is done.

Boynton[6] 1996 - Variable results in long term follow-up of conservatively managed isolated PCL injuries. Some patients are asymptomatic while others reported significant symptoms & articular degeneration.

Harner et al.[22] 1998 - Reconstruction of PCL is preferred in cases where PCL injury is associated with injuries to other structures of knee.

Klimkiewicz et al.[29] 1999 - Arthroscopic single bundle PCL reconstruction: University of Pittsburgh approach.

Petrie et al.[41] 1999- Arthroscopic double bundle PCL reconstruction: University of Pittsburgh approach.

Jari et al.[25] 2001 - Controversies exists regarding treatment of PCL deficient knees; emphasized the need for literature on the natural history of PCL deficient knees.

Wang[54] 2001 - PCL injuries combined with posterolateral instability result in early articular degeneration in untreated cases & hence reconstruction of the ligament with posterolateral structure is necessary for good functional outcome.

Dhillon et al.[16] 2003 - PCL avulsion # yield good results after stable fixation using posteromedial approach with minimal dissection.

Inoue et al.[36] 2004 - Occult mid-substance tear in patients with PCL avulsion injuries does not affect the stability of the knee postoperatively.

Wind et al.[56] 2004 - Suggested long term outcome studies for definite and best method of treatment for PCL injuries.

Shelbourne et al.[50] 2005 - In patients with isolated PCL injuries, subjective scores were independent of the degree of laxity. No definite protocol to identify cases which may have deteriorating knee function in the future.

Kashsani[26] 2006 –Pull-through suture technique is a good alternative in cases where the bony fragment is small and risk of communition is higher with usage of screw for fixation.

Piedade[42] 2007 - Residual laxity in postoperative patients implicates that PCL avulsion # should be treated as bone-ligament injury and not just as a bone lesion.

Patel et al.[40] 2007 - Isolated complete PCL tears can be managed non-operatively with good functional result in majority of patients at intermediate term follow-up.

Ali et al.[1] 2010 - Suggested open reduction & internal fixation of PCL avulsion # after diagnostic arthroscopy.

Fanelli et al.[18] 2010 - Treatment of PCL injuries is surrounded by controversy due to infrequent occurrence. Technical development led to enhanced results in PCL reconstruction.

Lamichhane et al.[34] 2012 - Modified Burks & Schaffer approach is a safer alternative than the classical one in fixation of PCL avulsion # using screw.

Bali et al.[3] 2012 - Open reduction & internal fixation yields a good functional outcome &a delay in presentation is not a contraindication to ORIF.

Yuan Chen et al.[9] 2012 - In PCL avulsion injuries, arthroscopic suture fixation is a reliable technique with good radiological and clinical outcome& low complication rate.

Wei Chen et al.[10] 2012 - Microendoscopy assisted reduction and screw fixation through a mini-incision for PCL injuries.

Broek et al[7]. 2012 - Suggested a novel technique on easy graft passage using Deschamp device and meniscal repair needle in PCL reconstruction without the aid of posterior portals.

DiFelice et al.[17] 2012 - Suggested an arthroscopic technique for torn posterior cruciate ligament in patients with multi-ligamentous injuries.

Pierce et al.[43] 2012 - No definitive guidelines for rehabilitation of non-operated PCL injuries/ after PCL reconstruction.

Gwinner et al.[20] 2014 - Fixation of PCL avulsion injuries using the TightRope device.

Attia et al.[2] 2014 - Fixation of PCL avulsion # through the posteromedial approach gives good functional and radiological results.

Ihle et al.[24] 2014 - PCL reconstruction for a chronic PCL insufficiency achieve an improved clinical result.

Sedeek et al.[48] 2014 - Isolated PCL injuries [Grades I & II] can be managed conservatively. More severe laxity and multi-ligamentous involvement warrants surgical intervention.

Barros et al. [4]2015 - Fixation of PCL avulsion # yield good functional results.

Huang et al.[23] 2015 – Suggested arthroscopic assisted anterior screw fixation for PCL injuries in cases with fragment size >20mm.

Chen et al.[11] 2015 – Suggested a modified technique for arthroscopic suture fixation of PCL avulsion injuries using posteromedial portal & double tibial tunnels.

Malempati et al.[35] 2015 - Suggested three arthroscopic techniques for PCL tibial sided avulsion #.

Won Lee et al.[30] 2015 - Suture bridge fixation technique using suture anchors combined with posteromedial approach can be considered for fixation of PCL avulsion #.

Khatri et al. [28]2015 - ORIF for PCL avulsion # through Burk & Schaffer approach produces good results. Early rehabilitation prevents arthrofibrosis.

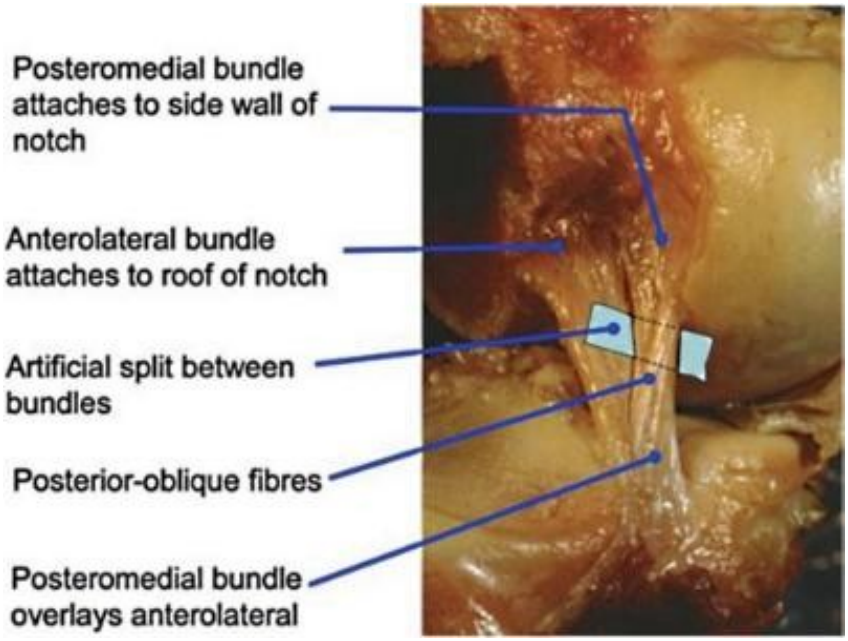
Sabat et al.[15] 2016 - PCL avulsion injuries fixed by either open or arthroscopic methods yield good clinical outcomes, radiologic healing & postoperative stability of knee.

Chahla et al.[8] 2016 - Anatomic double bundle PCL reconstruction using Achilles & anterior tibialis tendon allografts.

APPLIED ANATOMY

PCL is the largest of the ligaments of the knee. As the name suggest PCL is inserted posteriorly on the tibia. It is intrasynovial but extraarticular. It is located near the longitudinal axis of rotation and just medial to the center of the knee.[53] It is oriented vertically in frontal plane and inclined 35°to 45°in the sagittal plane; more vertical in extension & more horizontal in flexion.[53]

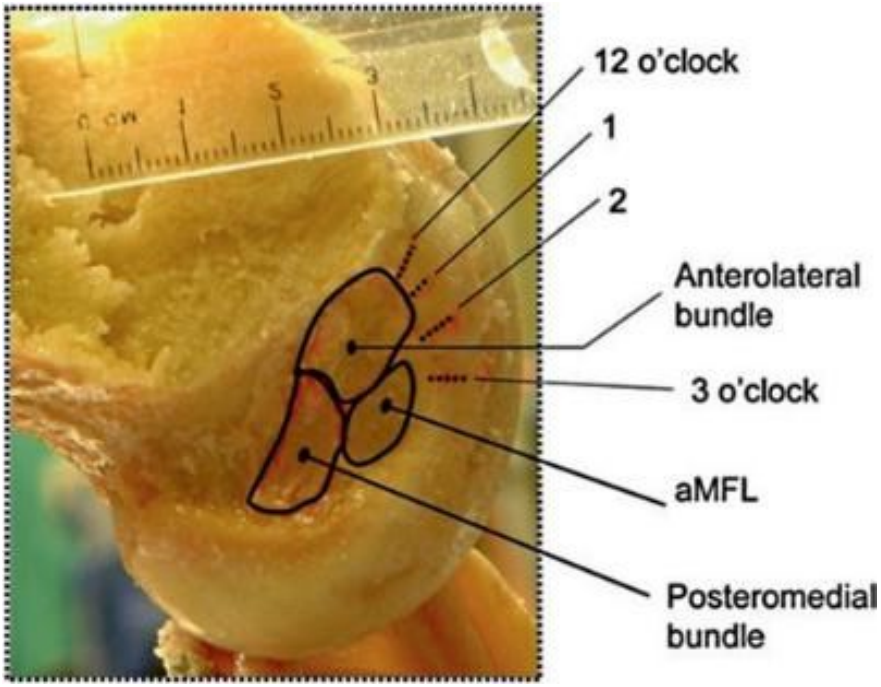
Average length of the PCL is 38mm[53]; average width is 13mm. It is narrowest in its midsection and widest at the femoral attachment, which averages 32mm.[53]

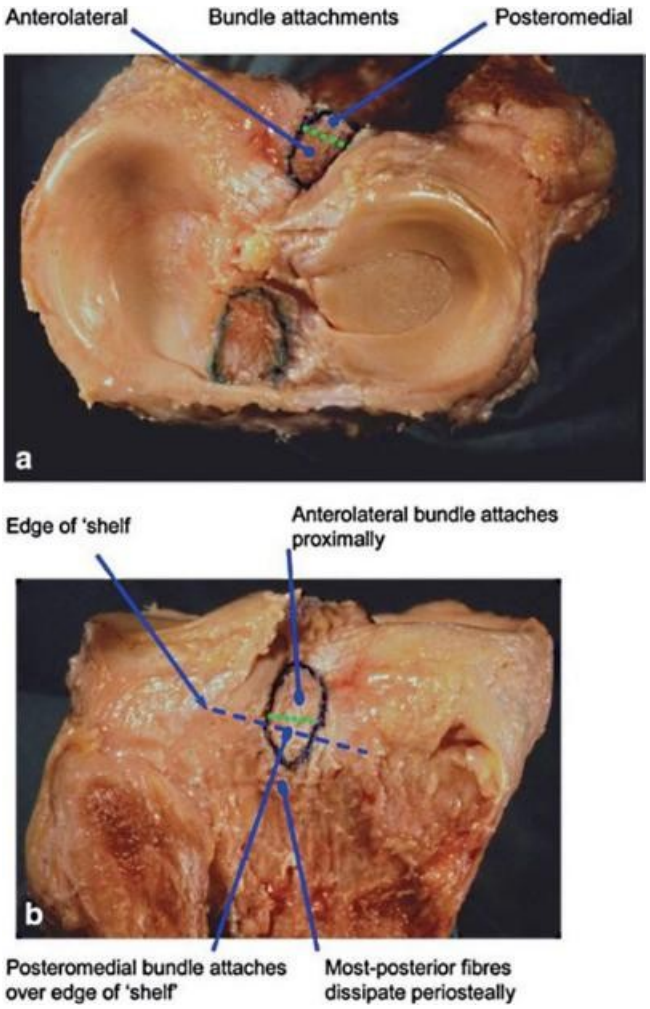


PCL is divided into two inseparable anterolateral [AL] and posteromedial [PM] bundle[53]. The AL bundle makes up the bulk of the

ligament, whereas the PM bundle is thinner. AL bundle is taut in flexion and lax in extension. PM bundle tightens in extension and loosens in flexion.

The PCL attaches between the two tibial plateaus in a depression in the posterior tibia approximately 1cm below the joint line. This depression is called as posterior intercondylar fossa. The femoral attachment is in the femoral notch on the medial femoral condyle. The femoral insertion site was recently mapped and found to be in the shape of a semicircle[53]. The femoral insertion site varies in shape and size but the tibial attachment size and shape are more consistent. The fibers attach in an anterior to posterior orientation in the tibial footprint and lateral to medial orientation to the femoral footprint[53].

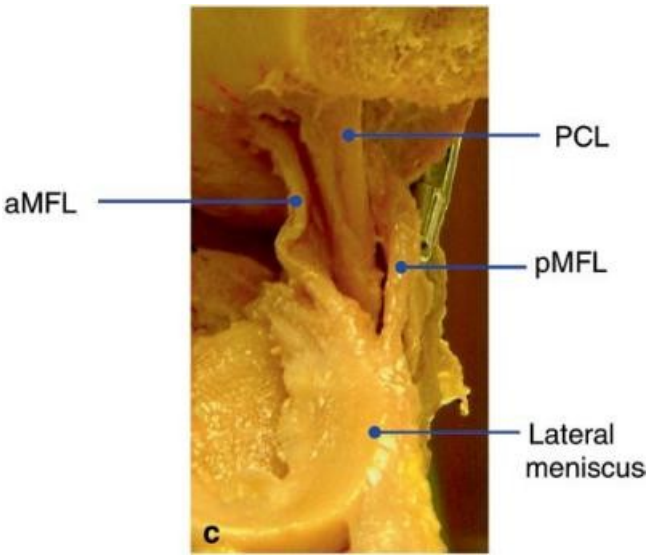




The AL bundle is biomechanically superior in its strength & stiffness when compared to the PM bundle; hence it is recommended for reconstruction of AL bundle in single bundle reconstruction of ligament. Also its cross sectional area is twice that of the PM bundle and is 2.1 times stiffer than the PM bundle[21].

Two mensicofemoral ligaments which vary both in size and presence are noted in association with PCL. Poirier and Charpey first described the mensicofemoral ligaments[53]. More than 93% of knees had

atleast one meniscofemoral ligament as per a recent anatomical study [74% ligament of Humphrey; 69% ligament of Wrisberg].[116]

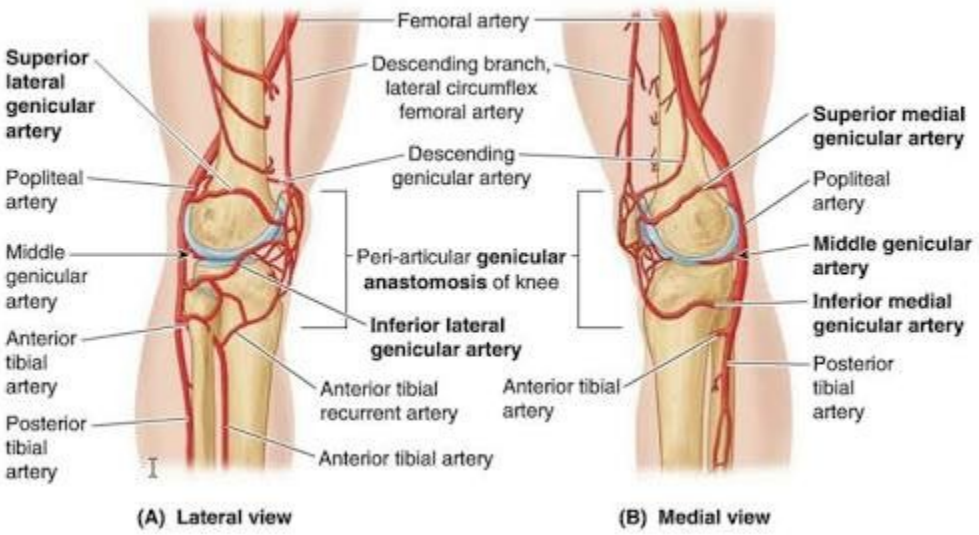


The anterior mensicofemoral ligament [Ligament of Humphrey] runs from the posterior horn of the lateral meniscus and inserts anterior to the PCL. The posterior mensicofemoral ligament [Ligament of Wrisberg] runs from the posterior horn of lateral meniscus [may also attach to tibia or posterior capsule] to the medial femoral condyle and inserts posterior to the PCL. The size of posterior mensicofemoral ligament is larger when compared to its counterpart as large as half the diameter of PCL[53].

The stiffness and ultimate load of the mensicofemoral ligaments are slightly greater than the PM bundle of PCL[21,117]. They offer up to 60% of the resistance to the posterior subluxation of tibia on knee flexion. They augment the strength of the PCL.

The posterior capsule attachment is within 1-2mm from the posterior aspect of the tibial attachment of the PCL[118]. An anterior septum made of fatty tissue wrapped in a thin synovial membrane separates the posterior capsule and the PCL. Around 7 to 10 mm from the posterior border of the PCL at 90^0 of flexion lays the popliteal artery[64]. Hence release of posterior capsule provides more working space during arthroscopic procedures and prevents neurovascular injuries.

The PCL is supplied by the middle genicular artery which arises from the popliteal artery. The synovial sheath vessels are a major blood source to the ligament[66]. The capsular vessels supply the base of the PCL. Minor vessels penetrate the ligament at multiple levels and then branch superiorly & inferiorly in the ligament.

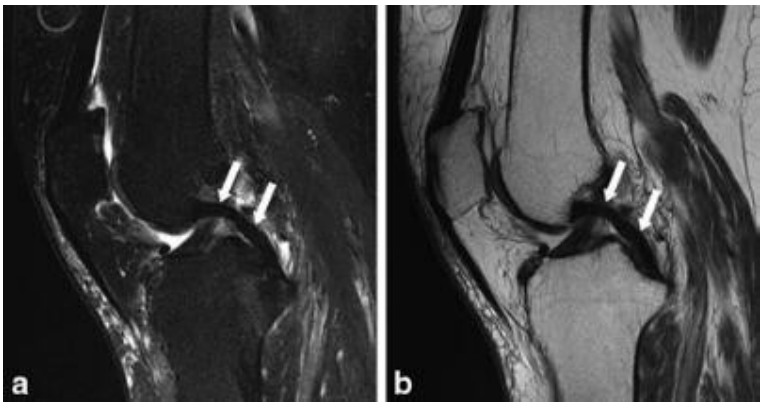


The posterior articular nerve, a branch of the posterior tibial nerve is a major nerve supply of the knee[68]. Receptors in the form of the fusiform corpuscles have been found on the surface of the ligament[68]. They were found to be concentrated more at the femoral attachment site of the ligament. Thus PCL injury also leads to neurologic disturbances in addition to mechanical symptoms by damaging the sensory afferent signals to the nervous system[62].

Congenital deficiency of the PCL can be seen associated with congenital longitudinal deficiencies of the lower limb. It is always associated with ACL deficiency[69]. This is of utmost significance in patients undergoing limb lengthening as it can result in anterior or posterior knee dislocation. These patients have shallow, hypoplastic intercondylar notch and poorly developed tibial spine on arthroscopic examination.

RADIOGRAPHIC ANATOMY

MRI is preferred in evaluation of ligamentous injuries of the knee. In T2- weighted images, PCL appears as a uniform band of very low signal density. In extension, PCL is lax and has a posterior convex curvature. Normal PCL in MRI is seen near the midline of the joint for atleast 2-3 consecutive images. The small oval structure anterior or posterior to the PCL is the meniscofemoral ligament. They are of low signal intensity. Coronal and axial images[69] are helpful in evaluation of the vertical portion of the PCL and its femoral and tibial attachments. PCL injuries are best seen in sagittal T2 weighted images.



High intensity fluid signal traversing the fibers is seen in a complete tear of the PCL with discontinuity in the fibers. Thickening of PCL with increased signal is seen in partial tear. ACL tear, menisci tear, collateral ligament injury and anterior bone contusion are most commonly associated with PCL tears[119]. MRI has 100% sensitivity and specificity in diagnosis of PCL tear[120].

BIOMECHANICS

The natural history of PCL deficient knee and progression of PCL injuries should be studied for recommending appropriate treatment guidelines. Knowledge about biomechanics of the ligament intact knee & PCL deficient knee aids the purpose.

PCL is a primary stabilizer of the knee. PCL along with the mensicofemoral ligaments, act as a primary restraint to posterior tibial translation after knee flexion >30°[71]. In PCL deficient knees there is excessive posterior translation of tibia in flexion when compared to very little posterior translation of tibia in extension. Also the popliteus muscle acts as a restraint to posterior tibial translation in PCL deficient knee[72]. PCL has a higher stiffness and tensile load compared with ACL. PCL has an important role in the "screw-home" mechanism of the knee.

Uncertainty exists in the role of PCL providing rotational stability to the knee. Kaneda et al.[73], found no increase in tibial external rotation on isolated sectioning of PCL but when anterolateral bundle alone was sectioned it shifted the axis of external rotation of the knee. On the

contrary, Li et al.[70], Harner et al.[72], Gupte et al.[74], Ogata et al[75]., found increased tibial rotation on isolated sectioning of the PCL. Thus PCL act as secondary restraint to tibial varus & external rotation in conditions when other ligaments are compromised. More biomechanical research is needed for evaluating the role of PCL.

In PCL deficient knee there is increased insitu forces in the popliteus complex and mensicofemoral ligaments. Also there is 52% increase[78] in the medial femoral condyle joint contact force under posterior tibial and axial loads. A mean pressure increase from 23.2 Pa to 28.0 and 34.8 Pa was also seen in the patellofemoral compartment with sectioning of the PCL and posterolateral corner respectively[78]. There was no increase of joint contact force in the lateral compartment. This explains the long term arthritic changes in the medial compartment and patellofemoral compartment of knee in patients with chronic PCL deficiency.

Hamada et al.[80], found increased association of meniscal tears [anterior horn of lateral meniscus being the commonest site] and chondral injuries [medial femoral condyle being the commonest site] in patients with presumed, high grade PCL injuries. Ochi et al.[81] found structural changes in ACL, in patients with PCL injuries. Shelbourne et al[82]. found no correlation between degree of laxity and radiographic changes and no difference in amount of time from the initial injury and

subjective knee score. On the contrary, Keller et al.[84] found correlation between progression of radiographic changes, subjective knee score and time since initial injury. Boynton et al.[6] found that some patients had significant symptoms and radiographic degeneration while others were asymptomatic with no loss of function. Thus he implied a bimodal distribution in the natural history of PCL deficient knees. Strobel et al.[85] found that in patients with combined PCL/PLC (posterolateral corner) injury there is increased medial degeneration than in patients with isolated PCL injury.

Some studies show very good outcomes for nonoperative treatment while others show activity associated knee pain in 90% of PCL deficient knees. Also in patients with PCL injuries there are ultrastructural changes in other ligaments which act as a restraint to the posterior tibial translation. Hence patients should be informed prior regarding the natural history of conservative management so that they can make a decision regarding their treatment.

Inoue et al.3[6] and Fontbone et al.[76] found no strength difference when compared to the contralateral uninjured knee in PCL deficient knees. But Hooper et al.[77] found loss of strength in the contralateral knee on evaluation of the peak knee extension torque at 60°/s in both knees in the PCL deficient group than the control group. MacLean et

al.[87] found the weakness of both the quadriceps and hamstrings in PCL deficient knees.

Both PCL and ACL are said to have proprioceptive receptors for the lower extremity movements. Clark et al.[88] found comparable loss of proprioception in PCL deficient knees when compared to the normal contralateral knee. Hence they stated that this may play a role in knee instability and progressive radiographic degenerative changes that occur in PCL deficient knee. Sarfam et al.[89] have also found statistically significant difference in the proprioceptive perception of PCL deficient and normal knees. But no literature has been published regarding the restoration of proprioception after reconstruction of PCL.

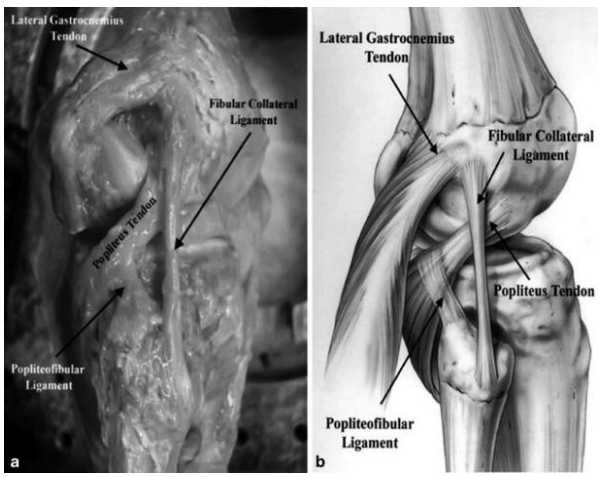
Paucity of literature exists in the role of compensatory contributions from other muscles in patients with PCL deficiency. Inoue et al.[36] found earlier activation of gastrocnemius muscle in PCL deficient knee during concentric isokinetic contractions, implying the role of gastrocnemius as a compensatory stabilizer during flexion in PCL deficient knees. Cain and Schwab[90] found 20% earlier quadriceps contraction in the gait cycle in a football player with PCL deficiency. Tibone et al.[51] too observed early activation of gastrocnemius-soleus complex in his study but statistical analysis was not performed. But Fontbone et al.[76] found no such differences in his study on 10 patients

with unilateral PCL deficiency during gait and vertical drop landing on one leg from a height of 30 cm. The normal knee was used as control.

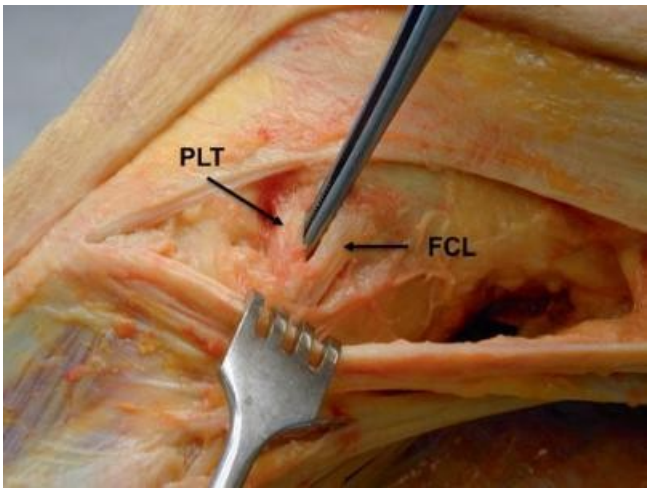
Around 60% of PCL injuries are associated with PLC injuries. On sectioning the posterolateral corner, the insitu forces in PCL increased by 2 to 6 times than in an intact knee. Thus, emphasizing the reconstruction of PLC injuries in patients with PCL injury as a future reconstructed PCL graft is at a high risk for failure. Harner et al. suggested that a double bundle reconstruction restores both normal knee laxity and PCL forces than single bundle reconstruction. Bergfeld et al.[58] found no biomechanical difference in double bundle or single bundle reconstruction.

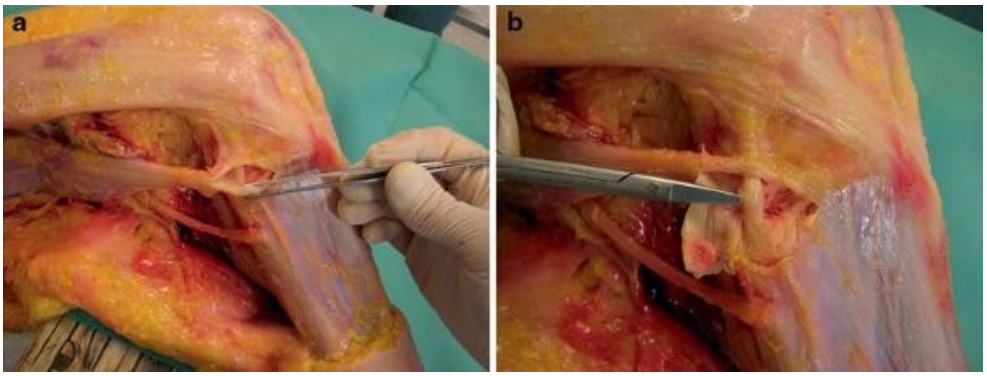
POSTEROLATERAL CORNER

The Posterolateral corner [PLC] consists of fibular collateral ligament [FCL], popliteus tendon [PLT], popliteofibular ligament [PFL], the Iliotibial band, biceps femoris and peroneal nerve as major landmarks.

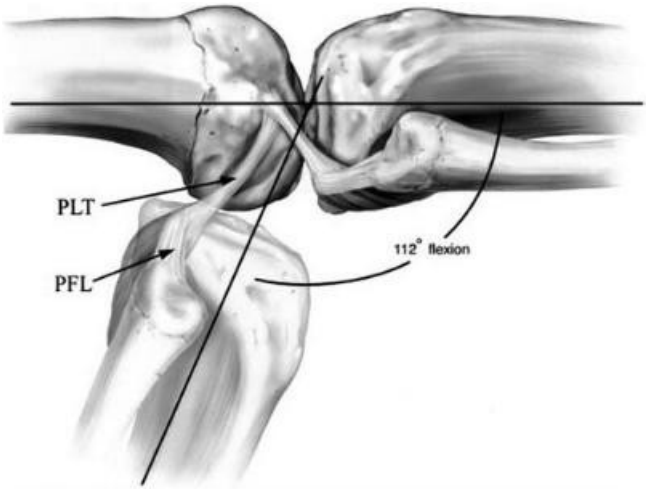


The fibular [lateral] collateral ligament is attached proximally on the femur, 1.4mm proximal and 3.1mm posterior to the lateral epicondyle, and distally in a small bony depression 28.4 mm distal to the tip of the fibular styloid[91]. Accessory fibers extend along the peroneus longus fascia distally.

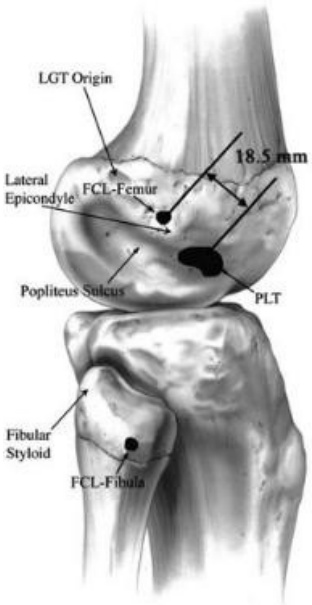




The popliteus tendon extends from the popliteus muscle and courses around the lateral femoral condyle through the popliteal sulcus becoming intra- articular. The tendon attaches deep and anterior to the FCL. The length of the popliteus tendon is measured to be 54.5 mm. Laprade et al.[91] found that, during extension the popliteus tendon disengaged from the politeal sulcus and reengaged at 112°flexion.



The politeofibular ligament extends from the musculotendinous junction of the popliteus muscle to the fibular head. It consists of two divisions: anterior and posterior[91]. The width of the posterior division is greater in its dimensions. The posterior division inserts 1.6mm distal to the tip of fibular styloid on the posteromedial downslope. The anterior division inserts 2.8mm distal to the tip of fibular styloid on the anteromedial downslope.



POSTEROLATERAL CORNER BIOMECHANICS

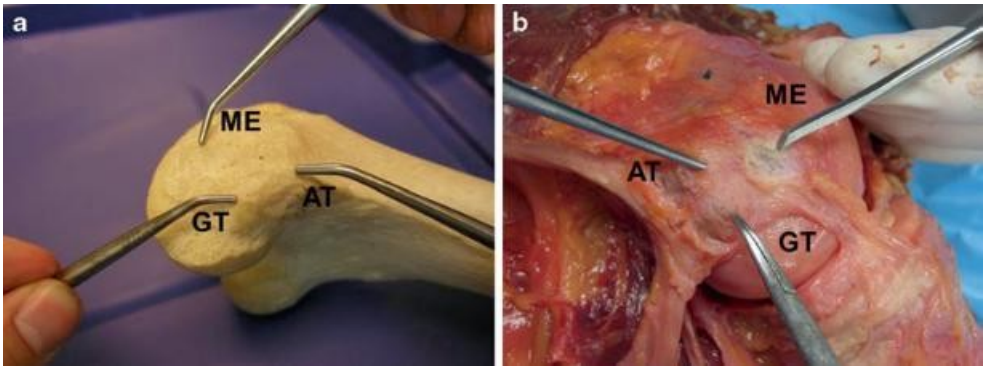
The FCL acts as primary varus stabilizer at 0°to 30°of knee flexion and as secondary restraint to external rotation. FCL injury leads to varus instability, medial compartment degeneration & medial meniscus tears. Coobs et al.[95] found increased varus rotation at 0,15,30,60 and 90°of knee flexion and external rotation at 60 and 90°after sectioning of the FCL.

The popliteus tendon acts like a tendon with both dynamic and static components. The tendon provides primary static stability to external rotation[93] and acts as a minor restrain to internal rotation, varus angulation and anterior translation.

The popliteofibular ligament acts as a primary restraint to external rotation at 30°to 60°knee flexion[92,96,97]. It acts as secondary restraint to varus angulation.

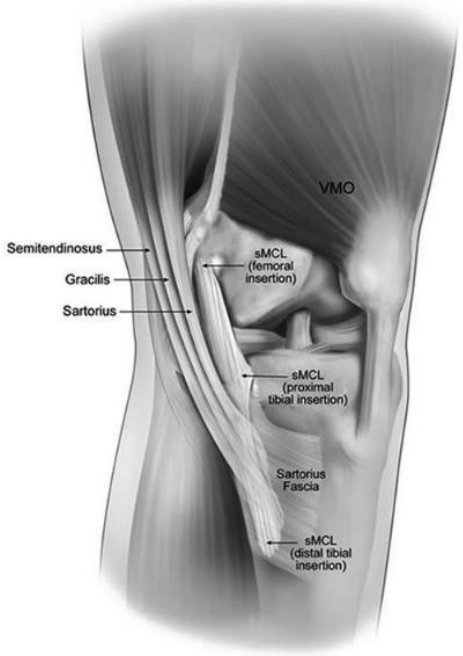
POSTEROMEDIAL CORNER ANATOMY

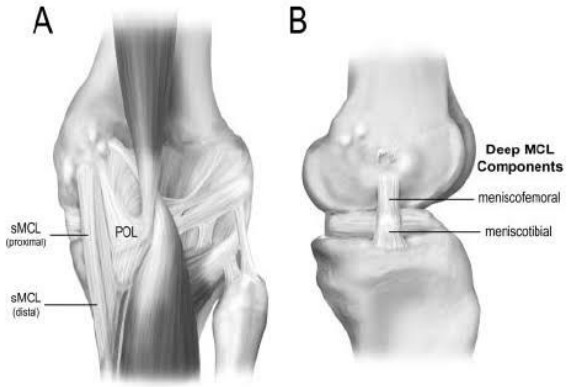
The superficial medial collateral ligament, the deep medial collateral ligament and the posterior oblique ligament constitutes the posteromedial corner[98]. The saphenous nerve courses through the medial aspect of the knee and should be preserved during surgical intervention. The three bony landmarks on the femur - the medical epicondyle, the adductor tubercle and the gastrocnemius tubercle[99] - are helpful in understanding the anatomy of the posteromedial structures.



The superficial medial collateral ligament is proximally attached to the femur and distally attached to the tibia after splitting into two components[100]. There is no attachment between the superficial and the deep MCL. The superficial MCL is attached proximally to the femur in a depression 3.2mm proximal and 4.8mm posterior to the medial epicondyle and 26.8 mm proximal to the femoral joint line. It has two attachments in the tibia[100]. The proximal attachment is to the deep soft tissue along with the anterior arm of the semimembranosus tendon. It is 12.2 mm distal to the tibial joint line. The distal attachment is anterior to the posteromedial crest of the tibia within the pes anserine bursa. It is 61.2 mm distal to the tibial joint line.

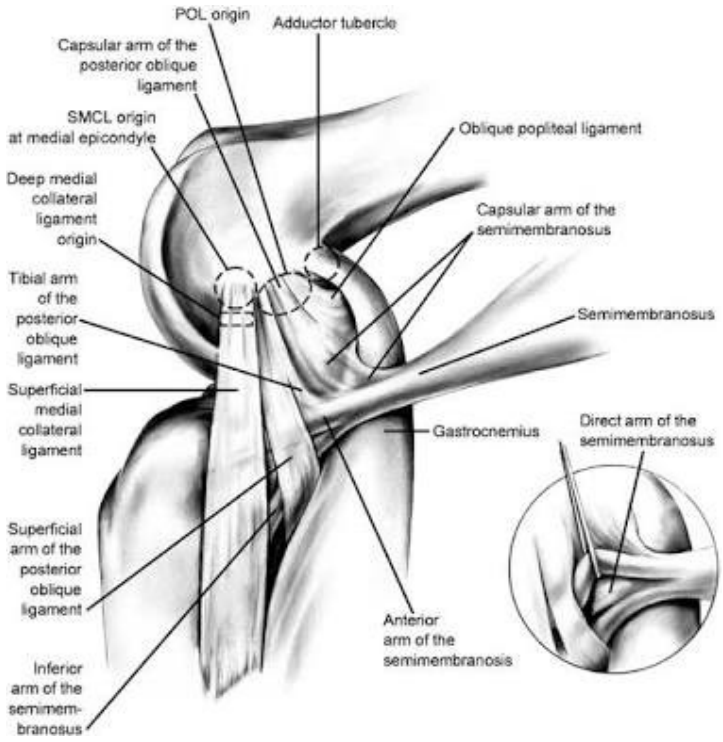
The deep medial collateral ligament is a thickening of the medial joint capsule. It is divided into mensicofemoral and mensicotibial components[100]. The mensicofemoral component is longer and is attached 15.7mm proximal to the femoral joint line[100]. The mensicotibial component is shorter and thicker and is attached 3.2mm distal to the tibial joint line.





The Posterior oblique ligament [POL] is a distinct separate structure from the superficial MCL[99]. It is attached proximally to the adductor tubercle and distally to the posteromedial aspect of tibia. It is divided into three arms[99] - the superior or capsular arm, continues with the posterior capsule and the proximal oblique popliteal ligament; the central arm, attaches adjacent to the articular cartilage of the posterior tibial plateau; the inferior or superficial arm, attached distally to the soft tissue covering the semimembranosus tendon and also to the

semimembranosus tendon insertion site. Its femoral attachment is 1.4mm distal and 2.9mm anterior to the gastrocnemius tubercle and 7.7 mm distal and 6.4 mm posterior to the adductor tubercle[100].



The central arm is the thickest portion of the ligament[98]. It arises from the distal semimembranosus tendon and runs posteriorly to attach to the posteromedial meniscus, mensicotibial deep MCL and posteromedial tibia. The capsular arm arises as a fascial expansion from the anterior and distal portion of the semimembranosus tendon, runs posterolateral to the mensicofemoral extension of the deep MCL. It has no osseous attachment but is attached to the soft tissue over medial gastrocnemius tendon, adductor magnus femoral attachment and adductor magnus tendon expansion to the medial gastrocnemius. The superficial arm arises as a fascial expansion from the anterior arm of the

semimembranosus tendon. It proximally merges with the central arm and distally merges with the distal tibial attachment of the superficial MCL into the semimembranosus tendon.

POSTEROMEDIAL CORNER BIOMECHANICS

The superficial MCL is a primary restraint to the valgus force. Its two divisions, proximal and distal, have distinct function. The two divisions share load at appropriate knee flexion and stress directions[102,103]. Thus these structures should be treated as separate ligaments in patients with injured ligaments.

The proximal division is the major contributor to the valgus restraint. It is the primary stabilizer in all knee flexion angles[103]. It acts as a secondary restraint to internal and external rotation at specific knee flexion angles. At 90^0 knee flexion it acts a restraint to external rotation and at 0, 30 and 90°it acts as a restraint to internal rotation.

The distal division of the superficial MCL acts as a major valgus restraint force at 60°knee flexion and also as a primary restraint to internal rotation at all knee flexion angles and external rotation restraint at 30°flexion.

The deep MCL also consists of two distinct divisions: meniscofemoral & meniscotibial. The meniscofemoral division alone acts as a primary restraint to internal rotation at 20, 60 and 90°knee flexion. It acts as a secondary restraint to valgus stress throughout the

range of knee flexion and as a secondary external rotation restraint at 30 &90°knee flexion[102,103]. The meniscotibial division acts as a secondary restraint to valgus stress at 60°knee flexion and to internal rotation at 0, 30 and 90°of knee flexion[102,103].

The posterior oblique ligaments acts as a primary restraint to internal rotation at all knee flexion angles[104]. It acts as a secondary restraint to valgus stress at 0 &30°, to external rotation at 30°knee flexion and restricts posterior tibial translation in extension [98,104]. The superficial MCL and the POL are the major structures which act as a restraint to valgus and rotational forces.

MECHANISM OF INJURY

Incidence of PCL damage in acute knee injuries is 1 to 40%. It is more frequent in trauma patients than in athletic injury patients. Isolated PCL injury is rare. Schultz et al. evaluated the mechanism of injury in patients with confirmed PCL insufficiency and found motor vehicle trauma in 45% & athletic injuries in 40% patients.

PCL is most commonly involved in high velocity injuries. Often it is associated with injury to other major structures. PCL injuries occur more commonly by three mechanisms: 1. posteriorly directed force on proximal tibia with knee in flexed position as in dashboard injuries; 2. Hyperflexion of knee in athletic individuals; 3. Hyperextension of knee with a valgus or varus force resulting in damage to collateral ligaments.

CLINICAL EVALUATION

In patients with PCL injured in isolation or associated with injuries to other ligamentous structures, the extent of knee instability and the functional limitations should be determined and evaluated for appropriate treatment. This may need not only a detailed history and physical examination but also advanced radiographic imaging.

A] History

A thorough history provides you with a provisional diagnosis. The history should start with index trauma, which is more significant. A detailed mechanism of injury can point out the structures which may be injured e.g. PCL bony avulsion & ligament injuries occurs mostly after direct impact anterior to the tibia on a flexed knee. Nature of velocity of injury whether road traffic accidents/ athletic injuries.

The examiner should enquire regarding what happened immediately following injury: Whether he was able to bear weight? Whether the knee swelling appeared immediately? Any instability felt in the knee? Did he see any prominence as in knee dislocation? Whether he was taken to hospital or some other place? Whether treatment was started immediately and what form - plaster application or bandaging?

Enquire about other symptoms such as feeling of stiffness, instability, locking of knees. Particular attention should be given to the patient occupation and their functional limitations - whether he was able to activities which he was able to do before the injury.

B] Physical examination

Apply the general principles of physical examination; look, feel &move. It helps to establish an anatomical diagnosis and the need for further investigations. At times it may also provide a realistic prognosis.

i) Look

In acute cases, look for any swelling, joint effusion, active bleeding, ecchymosis or open wounds. In chronic cases, look for muscle wasting, old scars. Knee dislocation may result in ‘dimple sign' over the medial aspect of the knee. Inspect the anterior aspect of tibia for any hematoma, which is more suggestive of the mechanism of injury [direct impact on tibia in a flexed knee] in PCL injuries. Look for the general alignment of the joint and the lower limb.

ii) Feel:

Ensure the adequacy of the vascular status of the affected extremity. Feel the temperature of the extremity using the dorsum of the wrist and compare with the unaffected extremity. Then palpate both the dorsalis pedis and the posterior tibia pulses. Look for the capillary

refilling in the toes. If any of them is found to be inadequate, vascular surgeon opinion should be sought with urgent vascular imaging.

Evaluation of the neurological function of the affected extremity is needed. The peroneal nerve is most commonly injured. Assess the power of the ankle and the great toe dorsiflexors. Look for adequacy of sensation in the first web space.

Palpation of knee joint must be done. Start gently in order to avoid exacerbation of pain. Then increasing pressure may be given. Look for joint line tenderness, patellar tendon and inferior pole of patella. Then proceed with bony palpation of distal femur, proximal tibia and fibular head. Elicit tenderness at points of attachments of the collateral ligaments.

iii) Move

Estimation of both active and passive range of motion is needed. The normal leg is first examined as it provides the standard for comparison. The examiner should avoid excessive force as it may incur severe pain to the patient and this induces a fallacy in evaluation of ROM. First ask the patient to move the injured leg as much as possible and then proceed with passive movement of the joint to assess the resistance to full flexion or extension. This evaluation shows the available ROM for ligamentous examination and also the need for preoperative physiotherapy to improve the ROM.

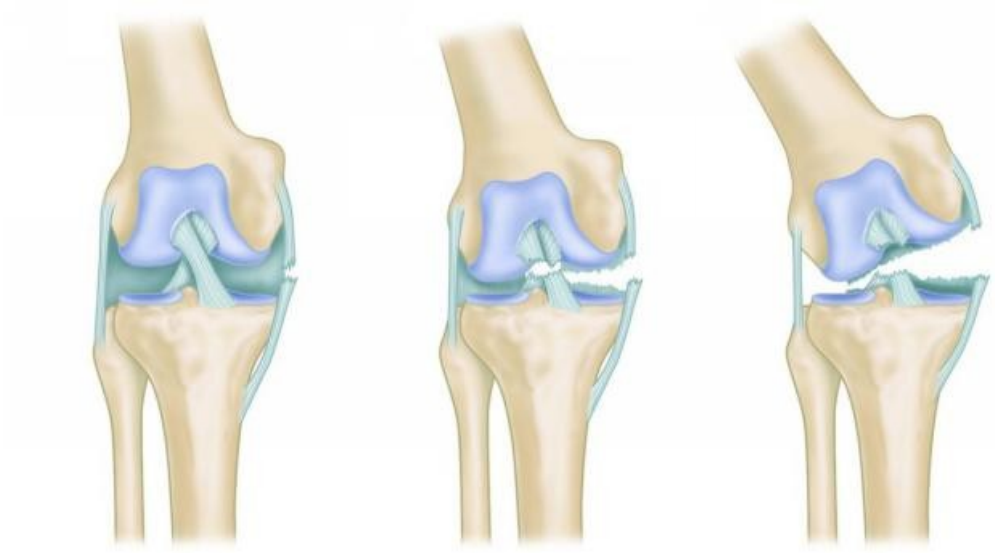
First, ask the patient to extend the knee. In meniscal pathology, hamstring spasm or extensor mechanism compromise there will be inability to extend the knee. Joint line tenderness at maximum flexion indicates meniscal pathology. Atleast90°knee flexion required for examination of the PCL.

iv) Special tests

1. Varus / Valgus stress test

Start at 0°flexion or hyperextension if possible. With the patient supine on the examination table, the extremity is abducted off the side of the table. With one hand around the lateral/ medial aspect of the knee and the other hand supporting the ankle, gentle valgus/ varus stress is applied to the knee and the quality of end point of the test is noted. If there is firm end point it infers that PCL and lateral and medial capsuloligamentous structures are intact. But if the knee has a soft or mushy end point to varus angulation, the posterolateral corner and the PCL are probably injured. If there is soft end point to valgus angulation, then the posteromedial corner and the PCL are probably injured.

With flexion of 30°the integrity of the collateral ligaments in isolation can be estimated, because the cruciate ligaments, posterolateral and posteromedial structures are relaxed in this position.

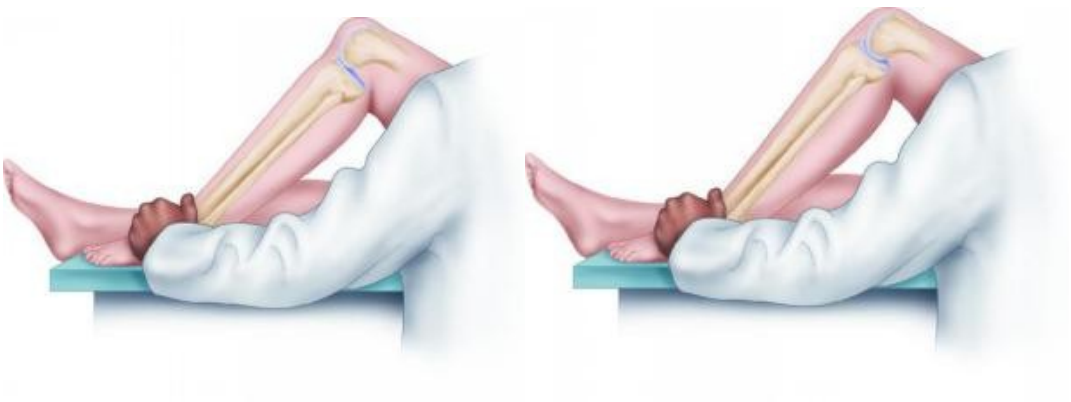


2. Posterior sag test:

It is performed with both the ipsilateral hip and knee flexed at 90°.If the PCL is injured, on inspection from each side it can be noted that the tibial plateau is translated posteriorly when compared to the femur, which is termed 'posterior sag'.

3. Quadriceps active test

With the patient supine, knee flexed to 90°, patient's muscles are completely relaxed. Ask the patient to make a gentle quadriceps contraction without extending the knee. In PCL insufficiency contraction of the quadriceps muscle will result in an anterior shift of the tibia of >2mm. At 90°knee flexion, the patellar ligament in the normal knee is oriented slightly posterior and contraction of the quadriceps does not result in an anterior shift. In patients with PCL deficiency, the patellar ligament is then directed anteriorly as the tibia sags into posterior subluxation.



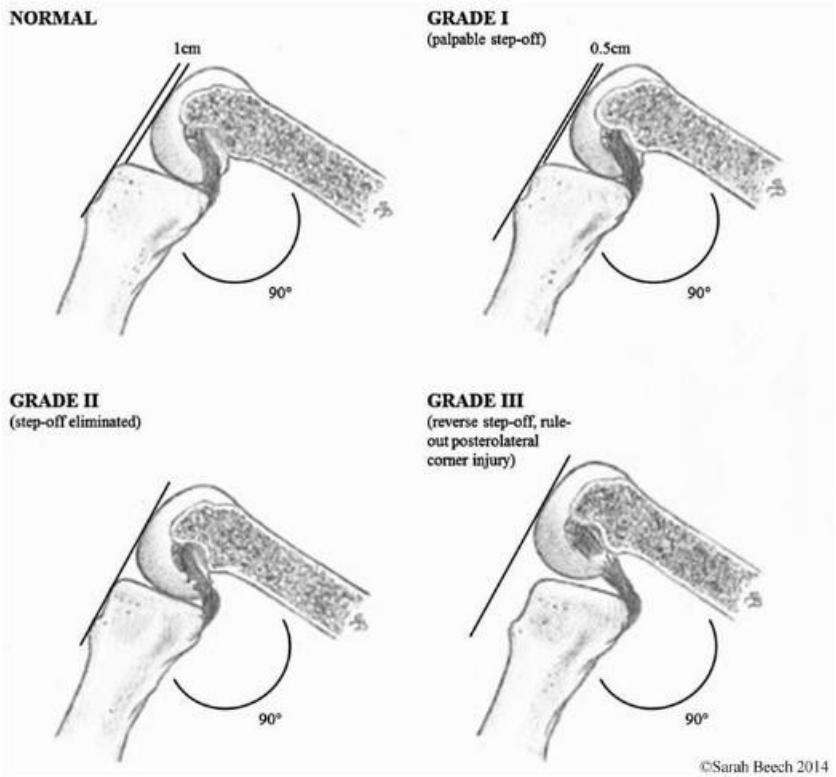
4. Posterior drawer test

It is done with the patient supine and the knee flexed to 90°, the foot is secured firmly in neutral position to the table by sitting on it. The fingers are placed encircling the posterior aspect of the proximal tibia into the popliteal fossa and both the thumbs are placed on either side of the patellar tendon to confirm the neutral alignment of the joint and to palpate for posterior subluxation on application of posterior stress. Usually the medial tibial plateau is 1cm anterior with respect to the medial femoral condyle. Loss of this step off indicates PCL insufficiency.First pull the tibia forward in order to feel the anterior shift of the tibial plateau. Then apply a posterior force on the proximal tibia and note the posterior movement of the tibia on the femur and feel the end point. Compare it with the opposite side. The extent of translation can be quantified according to the International Knee Documentation Committee [IKDC] values or based on grading of the step-off.

Fig: A posteriorly directed force is applied to proximal tibia

IKDC -Grading of joint translation

Normal	Nearly normal	Abnormal	Severely abnormal
0-2mm	3-5mm	6-10mm	>10mm



5. Dynamic posterior shift test

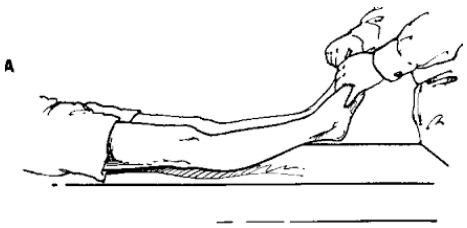
The main principle is that in patients with posterior ligamentous insufficiency hamstring contraction leads to posterior displacement of the tibia. The knee and hip are flexed to 90°leading to posterior displacement of the tibia. Now extend the knee. This displaces the axis of the pull anteriorly and the displaced tibia will reduce. This is indicative of posterior laxity, with or without additional posterolateral laxity.

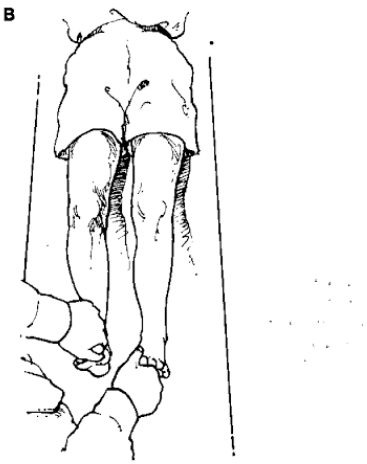
Figure 1. Tibia subluxated posteriorly by pull of tightened hamstring tendons

Figure 2. Tibia dynamically reduced as knee nears full exten-

6. External rotation- recurvatum test

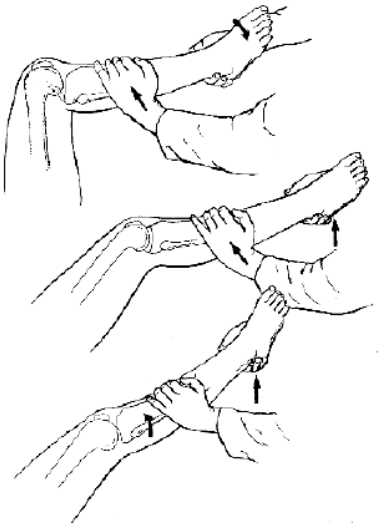
The examiner lifts both the extremity by holding the great toe and noting the degree of recurvatum and external rotation of the tibia that occur on the normal and the abnormal sides . It is positive in injuries to posterior cruciate ligament, posterolateral corner and lateral collateral ligament.





7. Reverse Pivot shift sign of Jakob, Hassler and Staubli

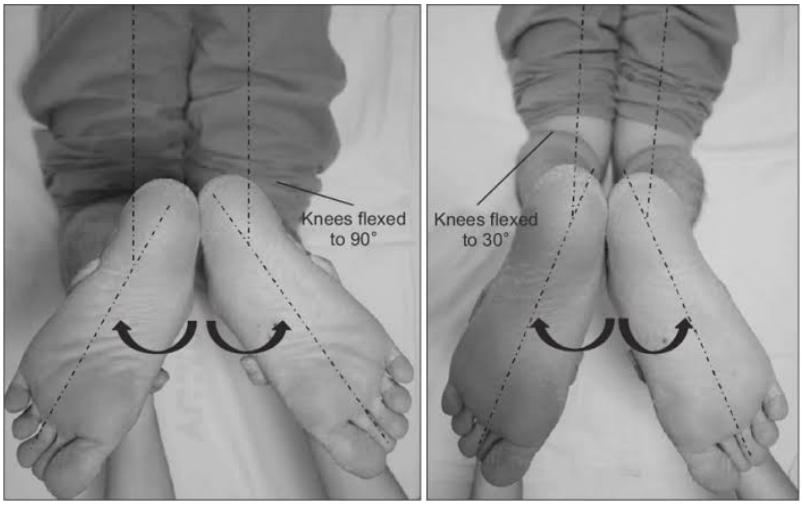
It is positive in patients with acute or chronic posterolateral instability of the knee. With the patient supine, the examiners right hand holds the right foot and ankle. The lateral side of the calf is supported with the palm of the left hand on the proximal fibula. The knee is flexed upto80°and the foot is externally rotated to cause the lateral tibial plateau to subluxate posteriorly in relation to the lateral femoral condyle. Then the knee is extended and a valgus stress is applied to the knee, with the examiners iliac crest used as a fulcrum. At around 20°knee flexion, the lateral tibial plateau is reduced in a jerk like fashion from a position of posterior subluxation and external rotation into a position of reduction and neutral rotation.



8. Dial test

It is done to evaluate the amount of external rotation of the tibia on the femur. It differentiates between isolated posterolateral corner

injury and a combined PCL and posterolateral corner injury. With the patient in prone position, flex both the knees to 30° and externally rotate both the feet. Compare with the uninjured side to assess for any increase in rotation. Then further flex the knee to 90°and repeat the manoeuvre. A positive dial test at 30°knee flexion with a normal dial test at 90°indicates an isolated posterolateral corner injury. If the test is positive at 90°it usually indicates a combined posterolateral corner and cruciate ligament injury.



v) Vascularity

Vascular injuries may occur in patients with multi-ligamentous knee injuries. Evaluation of Ankle Brachial Index [ABI] is helpful in earlier diagnosis of vascular injuries. The ABI is evaluated by measuring the systolic pressure in the affected leg at a level just proximal to the ankle and dividing this value by the systolic pressure in the ipsilateral arm. A value of >0.9 indicates adequate arterial perfusion.

ABI <0.9 in presence of abnormal physical findings like cold peripheries and feeble pulses warrants further investigations.

IMAGING STUDIES

A) Plane Radiography

A standard radiograph including anteroposterior, lateral and AP flexion 45°weight bearing views are taken. The radiographs may reveal any avulsion fractures, tibial subluxation, reverse segond's fracture, associated knee injuries, degenerative changes of the medial and patellofemoral compartments in chronic injuries.

Fig: Reverse segond's #

B] Computed tomography

CT scans are helpful in assessment of PCL injuries. Their role is important in ligamentous injuries with associated avulsions or fractures. Particularly, 3D reconstruction CT scan, delineate the nature of the avulsed fragment - whether single or communited and their exact location. This helps in defining the mode of management and the approach.

C] Magnetic resonance imaging

MRI is now considered as a gold standard, non-invasive imaging modality for assessing the ligamentous injuries of the knee. It clearly defines the specific site of ligamentous injury -proximal, distal or mid-substance. It also shows the location of bone oedema and the cartilaginous state which may be helpful in ascertaining the prognosis. They provide only static images and so may not be able to determine the function of the knee. It is also unreliable in evaluation of chronic injuries.

PCL injuries are classified into intrasubstance tear, partial tear or complete tear and avulsion #. Intrasubstance tear shows oedema and haemorrhage within the ligament. Partial tears show interruption of one of the margins of the ligament. Complete tears show loss of continuity of the ligament and increased signal at the margin of the tear. Avulsion at the tibial attachment side is more common and the ligament is seen to be retracted along with its bony fragment.

Assess the medial structures for any signal changes and their location which is indicative of oedema and haemorrhage. The continuity of superficial MCL, deep MCL and posterior oblique ligament are assessed. This should be correlated with clinical findings.

Then assess the lateral and posterolateral structures of the knee [LCL, biceps femoris, iliotibial band, popliteus complex and capsular structures]. Look for any signal changes or any discontinuity in the ligaments.

Meniscus is then completely assessed for any tear or root avulsions. It is not uncommon to find associated meniscal tears with PCL injuries. Early identification and concurrent treatment is mandatory for all meniscal tears as they may prevent postoperative rehabilitation in PCL reconstructed patients.

MANAGEMENT

A] Non -operative management

Uncertainty still exists in the protocol for non-operative management of PCL injuries. Due to lack of literature regarding the natural history of the disease, there are no clear guidelines for treatment.

For bony avulsion injuries, when the displacement of the bony fragment is <2mm in a CT scan then non-operative treatment is preferred, mostly in the form of above knee slab to reduce the swelling. Later it is changed to a tube cast. Non-weight bearing for 3 weeks is advised.

For isolated PCL injury, which is rare, conservative management is preferred in patients with Grade I and Grade II laxity. It is treated with splinting and protected weight bearing, followed by early range of motion and quadriceps strengthening.

B] Operative management

i) Avulsion injuries

PCL bony avulsion injuries needs fixation when the fragment is >2mm in CT scan. Fixation may be done by open / arthroscopic method. Implants used may also be consider ed between screw and non-absorbable suture. It depends on the preference of the surgeon.

ii) Open approach:

Modified Burks & Schaffer approach was preferred. Patients were positioned in the prone position. A transverse incision 3-4cm long was made across the knee flexion crease. The incision was then carried distally from the medial edge of the transverse component in line with the hamstring tendons to create an inverted L-shaped incision. The underlying small saphenous vein and medial sural cutaneous nerve were isolated and protected.

The deep fascia was incised longitudinally along the lateral border of the medial head of the gastrocnemius. A plane was created just along the lateral border of the medial head of the gastrocnemius by blunt retractor. Aggressive retraction must be avoided.

The posterior knee capsule and the oblique popliteal ligament were identified and a vertical incision was made on the capsule to

expose the avulsed bone fragment. The fracture bed was cleared off clots and the avulsed fragment was repositioned into the bed provisionally with a 1.5mm Kirschner wire, followed by final fixation with 45-55mm long, 4mm partially threaded cannulated cancellous screw with the washer. In case of communition 2 to 3 screws were used to fix each fragment separately. The reduction and hardware position were then checked with fluoroscopy. The disappearance of posterior laxity was also noted. Then the wound was closed in layers and sterile dressing was applied.

2. Arthroscopic screw fixation

The patient was positioned supine on the operating table with the affected knee mounted on a knee holder at 90° flexion. High parapatellar, anterolateral and anteromedial portals were created. Diagnostic arthroscopy was performed and the status of the menisci, cartilage and ligaments was noted.

Once both the ACL and PCL were identified, the knee was placed in 70°flexion and a shaver was used to resect the synovium just above the ACL to enter into the posterior compartment of the knee. Care was taken to keep both the cruciate ligament fibers undamaged. Then, the posterior knee septum was removed and a single posteromedial portal was created after localization of the portal site by a spinal needle with the knee at 90°flexion.While the surgeon was viewing from the anterolateral portal, a PCL elevator was inserted through the AM portal and the posterior knee capsule was elevated, carefully working behind the PCL and the avulsed fragment.

A PCL tibial angled drill guide was placed through the AM portal with its tip placed 2 to 4mm distal to the level of fracture bed. A guide wire was drilled and the PCL tibial angled drill guide was removed. The tip of the guidewire was protected with the PCL elevator passed through the posteromedial portal. A 2.5 mm tunnel was drilled over the guide

wire and 60-65mm long 4mm partially threaded cannulated cancellous screw was inserted while applying an anteriorly directed force to the posterior tibia. Then the portals were removed and sites were closed.

3. Arthroscopic Suture Fixation

Under spinal anaesthesia and the patient in supine position, a thigh tourniquet was applied. Clinical examination under anaesthesia was done and findings were confirmed. Routine arthroscopic examination of knee joint was carried out through the anteromedial and anterolateral portals.

Two posteromedial portals were created; one 3cm above the joint line and the other at the level of the joint line. The fracture bed was identified by the arthroscope introduced through the high posteromedial portal. The debridement of the fracture bed and bony fragment was carried out through the low portal.

Through a 2cm oblique incision medial to the tibial tubercle, the PCL guide at an angle of 55° was inserted to position the tip of the guide at the medial border of the tibial bed. Then a 2mm guide wire was drilled to the edges of the tibial bed. Another 2 mm guide wire was inserted just lateral to the edge of the fracture bed. No.2 ethibond suture was looped around the PCL through the anterolateral portal. The sutures were retrieved one at a time through the low posteromedial portal. The

avulsed fragment along with PCL was secured to the tibial bed by completing the knot.

A 4.5mm cannulated drill bit was used to overdrill the k-wires. The sutures were retrieved one in a tunnel using the suture grasper via the same. Now the knee is flexed to 90°and an anteriorly directed force was applied to the tibia. Then the sutures were tied over the tibial cortex between the two tunnels.

ii) Ligament Tears

Arthroscopic Single Bundle Reconstruction

Patient in supine with a tourniquet applied high around the thigh, regular arthroscopic portals were made. Internal bony notchplasty was done for a better view of the PCL. The posterior capsule was elevated using a curved curette from its attachment through the posteromedial portal.

Hamstring graft was used. The adequate length of the graft was prepared. Mostly a graft of length upto 40mm may be needed. The tibial tunnel was made using the PCL drill guide. The tip of the guide was placed 10-12mm below the joint line in the PCL fossa. At 60° angle starting just inferior and medial to the tibial tuberosity, the guide wire was drilled upto 1cm less than the distance measured on the guide system. The final distance of the pin was achieved by gentle tapping. During this procedure a curette was placed through the posteromedial

portal to prevent damage to the neurovascular structures. Then the guide wire was overdrilled according to the graft size.

The femoral tunnel is located 8mm proximal to the articular cartilage at 1o'clock position on the right knee and at the 11 o'clock position on the left knee. Using the femoral drill guide, femoral tunnel was drilled.

Then a 26-gauge stainless steel wire was passed through the tibial tunnel into the joint. The graft was retrieved into the joint with the help of the stainless steel wire. Then using grasper through the femoral tunnel the graft was directed into it. Then the knee was put through a range of motion and made sure there was no more than 3mm of graft pistoning.

Now the femoral side of graft was fixed with an interference screw/ endobutton. Then maintaining the tension of the graft, the knee was put through a range of motion for 20cycles. The tibial side was fixed with an interference screw and the portals were closed after a thorough lavage of the joint.

MATERIALS AND METHODS

Place of study	:	Institute of orthopaedics and Traumatology, Rajiv Gandhi Government General Hospital, Chennai.
Type of study	:	Prospective and retrospective study
Sample size	:	12 (Retrospective -8, Prospective -4)
Period of study	:	Prospective study 2016-2018, Retrospective study from 2014

INCLUSION CRITERIA

1) Posterior cruciate ligament tear

2) Avulsion of the ligament from tibial / femoral attachment

3) Bony avulsion of the ligament from tibial/ femoral attachment

EXCLUSION CRITERIA

1) Paediatric population

2) Patients with arthritic changes evident in the radiograph of the knee

3) Open injuries

4) Associated fractures of proximal tibia & distal femur

PRE-OPERATIVE EVALUATION

In acute presentation after hemodynamic stabilization patients were subjected to the following:

- Detailed clinical evaluation including history and physical examination
- Radiographs of the knee - anteroposterior and lateral views
- CT scan of the knee with 3D reconstruction
- MRI of the knee joint

For avulsion injuries the choice of fixation depends on the location and size of the fragment. For fragment size >2cm screw fixation is preferred. In case of comminution, non-absorbable suture fixation is preferred.

For ligamentous injuries arthroscopic single bundle reconstruction was preferred. The choice of graft used was semitendinosus and gracilis.

Implants & Instrumentation

1) 4mm partially threaded cannulated cancellous screws
2) Non- absorbable sutures [Ethibond No.2]
3) Standard 4mm 30°arthroscope with camera and light settings.
4) Pneumatic tourniquet

POSTOPERATIVE PROTOCOL

i) PCL Avulsion Injuries

- 0 - 3 weeks: Long knee immobilizer was given in the immediate postoperative period with toe touch weight bearing. Quadriceps strengthening and isometric exercises.

- 3-6 weeks: Assisted ROM of knee upto30°then progressively increasing upto120°at the end of 6 weeks.

- After 6 weeks: Discontinue the brace and return to strenuous activity is allowed after radiologic healing.

ii) Ligament Injuries

Phase I (0-8 weeks)	• Non weight bearing x 3-4weeks • Partial weight bearing at 4thweek • Brace in full extension 24/7 x 3-4 weeks • Passive ROM started at 4thweek • Patella mobilization • Quadriceps sets/ SLR with brace • Isometric abdominal exercises
Phase II (8-16weeks)	• Closed chain strengthening 0-60° • Stationary bike for ROM without resistance • No open chain or isolated hamstring strengthening • Balance and proprioceptive training (single leg) • Active knee flexion upto 110°

Phase III (4-8months)	• Closed chain quadriceps exercises with increase resistance • Isolated hamstring exercises after 6th month. • Progressive hip, core and proprioceptive training. • Plyometric and agility exercises between months 6 and 7.
Phase IV (9months to 1year)	• Continuation of strengthening • Sport specific drills at 50% intensity

FOLLOW-UP

Patients were followed at 4 weeks, 12 weeks and 6months. Each time during the visit patients were subjected to the following:

1) Clinical evaluation: Look for any tenderness around the knee. Any abnormal swelling and surgical wound site discharge must be noted.

2) Functional ability of the patient [from history and scoring system]

3) Radiographic assessment: Antero-posterior and lateral views of the knee are taken. Look for any screw loosening, step- off of the fragments from the fracture bed and loosening of interference screw in patients who underwent ligament reconstruction.

FUNCTIONAL ASSESSMENT AFTER SURGERY

LYSHOLM KNEE SCORING SCALE[123]

1. LIMP	
-I have no limp when I walk	5
-I have a slight or periodical limp when I walk	3
-I have a severe and constant limp when I walk	0
2. USING CANE /CRUTCHES	
-I do not use cane or crutches	5
-I use cane or crutches with some weight bearing	2
-Putting weight on my hurt leg is impossible	0
3. LOCKING SENSATION IN THE KNEE	
-I have no locking and no catching sensations in my knee	15
-I have catching sensation but no locking sensation in my knee	10
-My knee locks occasionally	6
-My knee locks frequently	2
-My knee feels locked at this moment	0
4. GIVING WAY SENSATION FROM THE KNEE	
-My knee never gives way	25
-My knee rarely gives way, only during athletics or other vigorous activities	20
-My knee frequently gives way during athletics or other vigorous activities, in turn I am unable to participate in these activities	15
-My knee occasionally gives way during daily activities	10
-My knee often gives way during daily activities	5
-My knee gives way every step I take	0
5. PAIN	
-I have no pain in my knee	25
-I have intermittent or slight pain in my knee during vigorous activities	20
-I have marked pain in my knee during vigorous activities	15
-I have marked pain in my knee during or after walking more than 1mile	10

-I have marked pain in my knee during or after walking less than 1mile	5
-I have constant pain in my knee	0
6. SWELLING	
-I have no swelling in my knee	10
-I have swelling in my knee only after vigorous activities	6
-I have swelling in my knee after ordinary activities	2
-I have swelling constantly in my knee	0
7. CLIMBING STAIRS	
-I have no problems climbing stairs	10
-I have slight problems climbing stairs	6
-I can climb stairs only one at a time	2
-Climbing stairs is impossible for me	0
8.SQUATTING	
-I have no problems squatting	5
-I have slight problems squatting	4
-I cannot squat beyond a 90°bend in my knee	2
-Squatting is impossible because of my knee	0

OBSERVATION

AGE INCIDENCE AND DISTRIBUTION

Age group	No. of patients
<20	1
20-30	6
30-40	4
40-50	1

SEX INCIDENCE

All patients were males.

MODE OF INJURY

Majority of injuries were due to road traffic accidents [collision] followed by accidental fall from two wheeler.

Road traffic accidents [collision]	Accidental fall
9	3

SIDE PREDOMINANCE

Right	Left
8	4

ASSOCIATED INJURIES

Associated injuries	No. of patients
Vascular injuries	Nil
Long bone Fracture	2

NATURE OF INJURY

	Bony avulsion	Ligament tear
No. of patients	10	2

MODE OF FIXATION FOR AVULSION INJURIES

Avulsion injuries	No. of patients
Open approach	8
Arthroscopic approach	2

TYPE OF FIXATION FOR AVULSION INJURIES

Avulsion injuries	No. of patients
4mm partially threaded cannulated cancellous screws	9
Non-absorbable suture [ethibond No.2]	1

LIGAMENT RECONSTRUCTION

Ligament reconstruction	No. of patients
Arthroscopic single bundle reconstruction	2

Average no. of days before fixation in avulsion injuries: 14.75 days

COMPLICATIONS

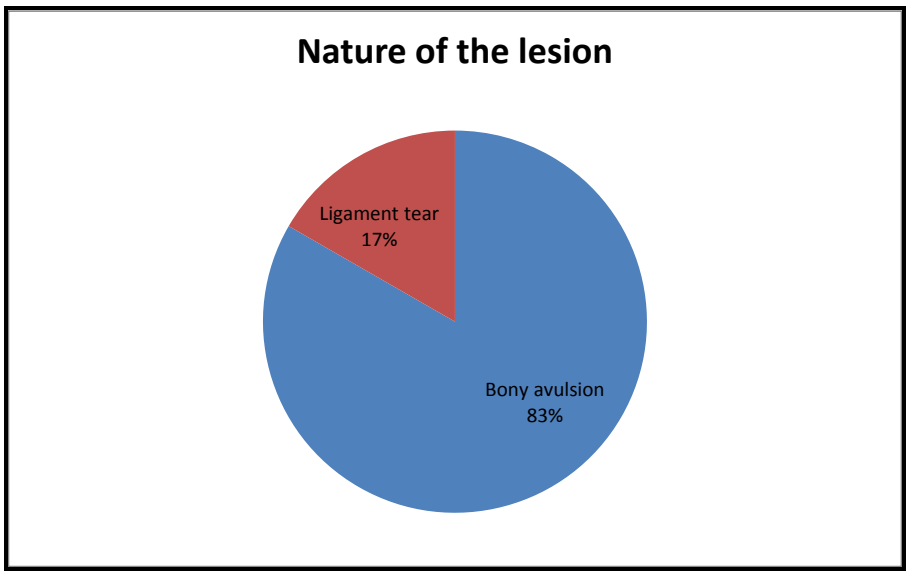
None of the cases reported any complications during their course of follow-up. There were no cases of neurovascular injuries or infections associated with surgery.

DISCUSSION

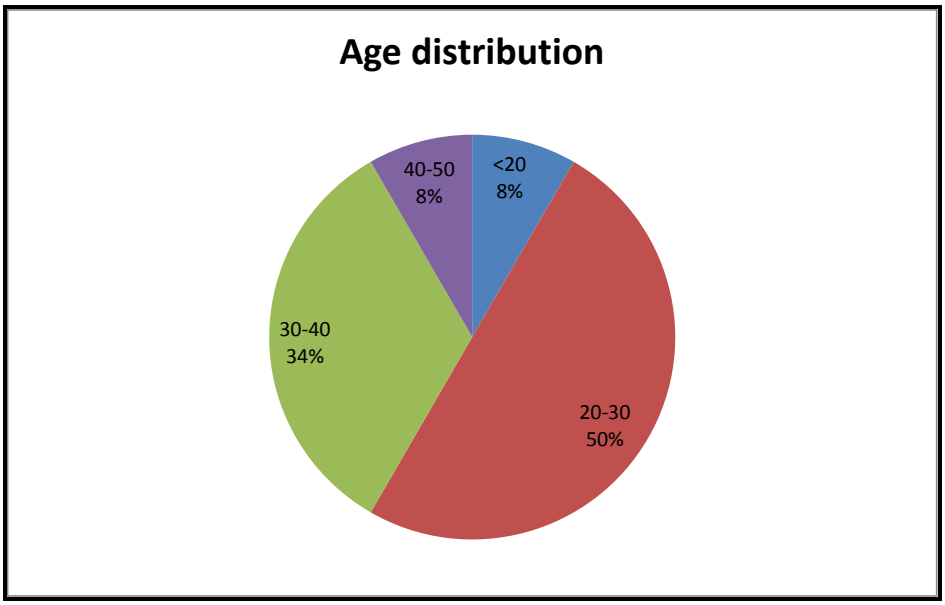
Isolated PCL injuries relatively to ACL injuries are uncommon; they are generally combined with other knee injuries. We report outcome analysis of 12 patients with posterior cruciate ligament injuries who were surgically treated in our institution from 2015 to 2018.

Surgical treatment for acute PCL injuries was suggested by Fanelli et al.[18] which includes, PCL insertion site avulsion [tibia & femur], >Grade II laxity and when combined with other structural injuries.

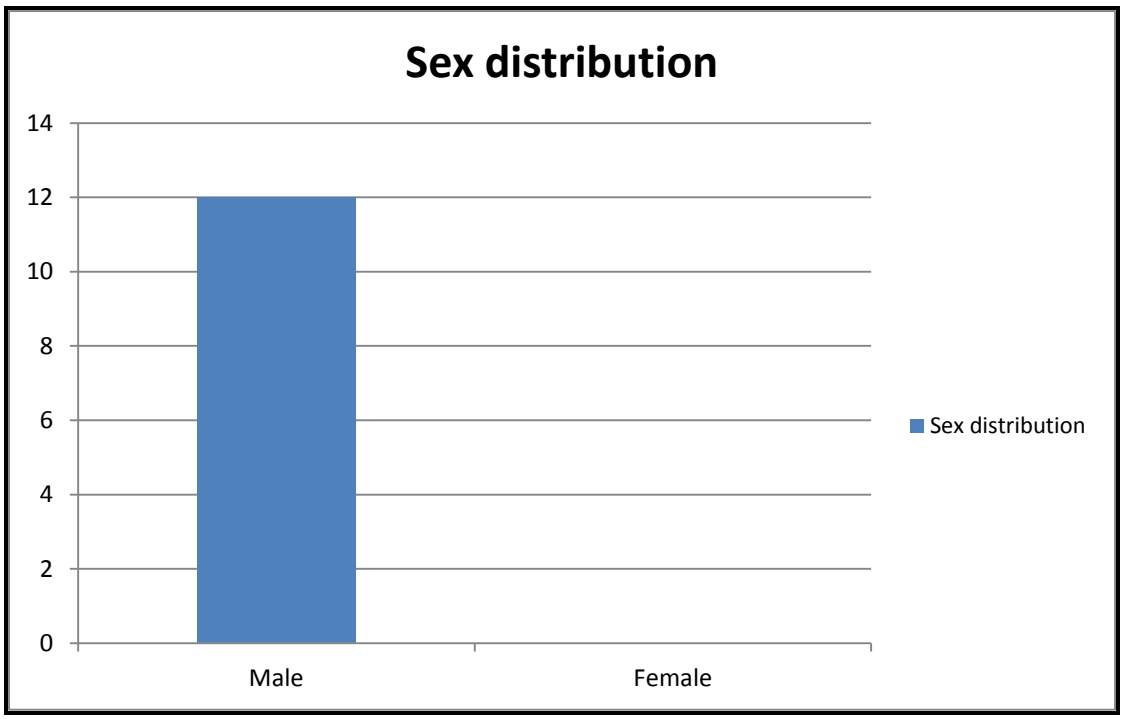
We did a complete descriptive analysis according to age, nature of injury and interval between injury and surgery. In our study out of the 12 cases, two were ligamentous injuries while 10 cases were bony avulsion injuries, indicating its higher incidence than ligamentous tears,similar to the study by Bali et al. [3] . Tibial side PCL avulsion are more common than the femoral side.



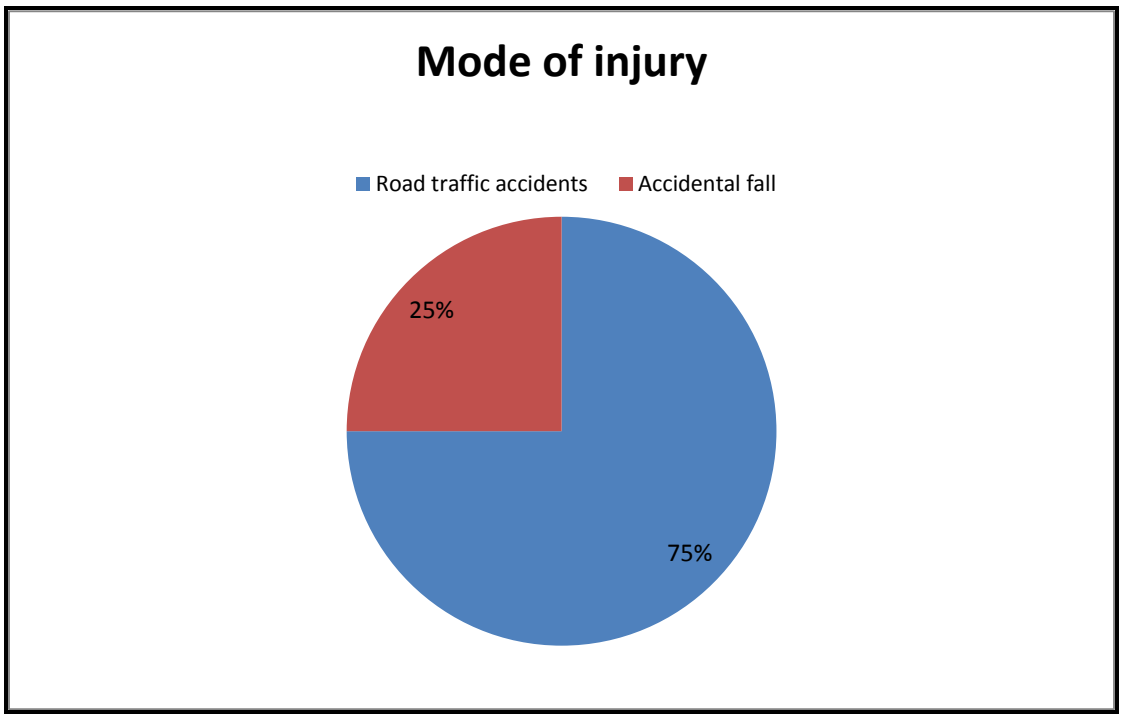
In our study group the commonest age group was 20-30yrs. The mean age in our study was 30.3 years [range, 18 to 42], whereas D.Sabat et al [15] reported an average age of 34.2 years [range, 18 to 54].



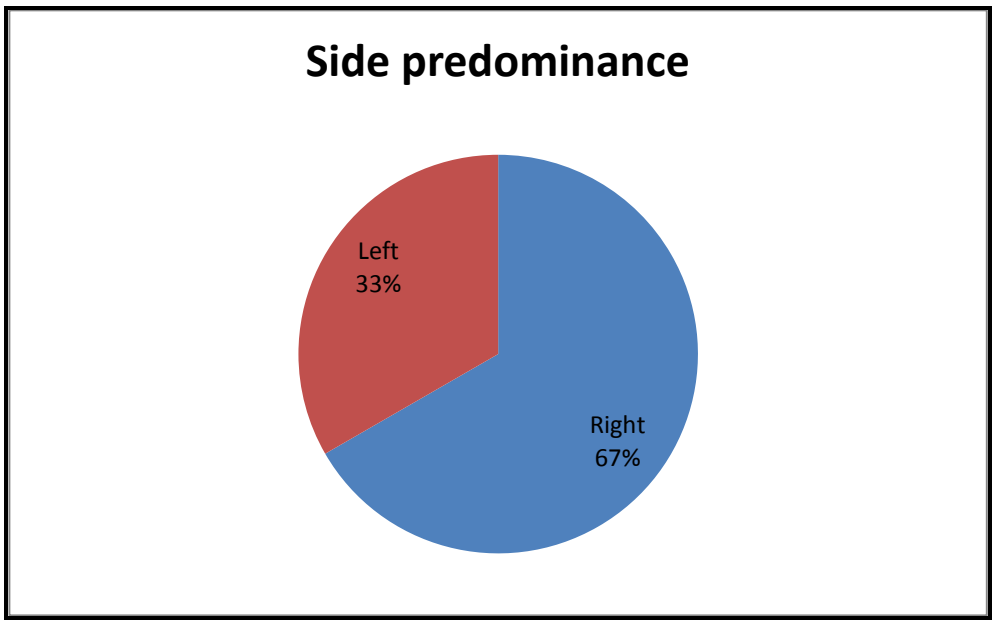
Only males were affected in our study, it may be due to high preponderance of road traffic accidents in males, even D.Sabat et al.[15] & H.Seitz et al.[49] reported a high incidence in male. H.Seitz et al [49] studied a total of 30 patients of which 23 were males. D. Sabat et al.[15] studied 47 cases of which 43 were males.



Fall on a flexed knee due to road traffic accidents [collision] or an accidental fall accounts for most of the PCL injuries. In developing countries where two-wheelers are the most common mode of commute, this remains the most common mechanism for PCL injuries including bony avulsion. We had 75% of patients due to road traffic accidents [collision] & 25% were due to accidental fall from two-wheeler. There were no reported cases of athletic injuries. D.Sabat et al.[15] reported 38 motorcycle related injuries, 4 sports related injuries and 5 caused by falls. H.Seitz et al.[49] reported 15 motorcycle related injuries, 11 due to car accidents and 4 caused by falls.

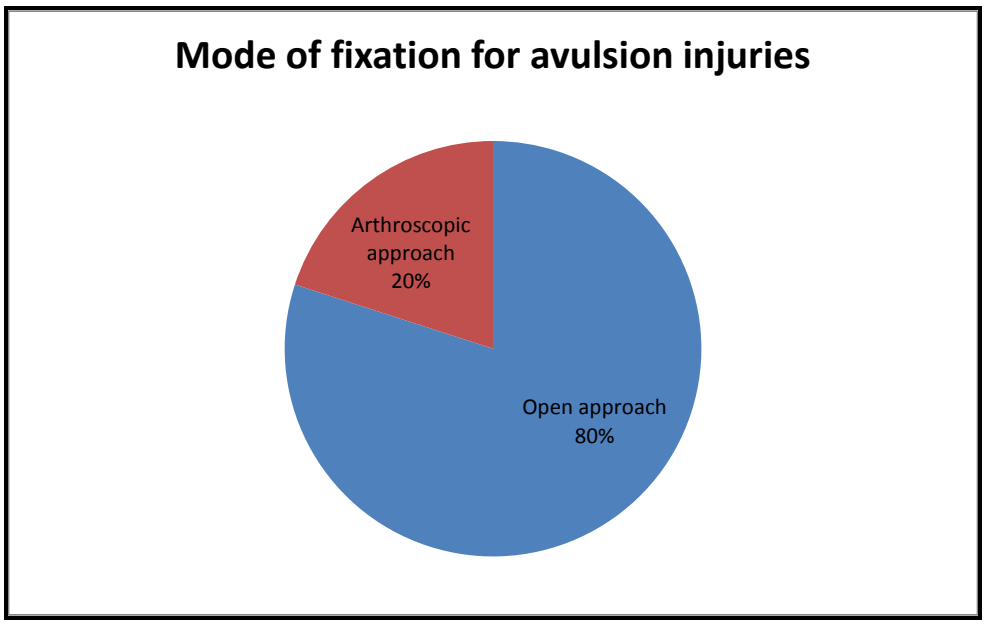


In our study right side PCL was found to be involved more common than the left side. Two of our patients had associated injuries. These were long bone fractures; but no vascular injuries were reported in our study. D.Sabat et al.[15] reported no associated popliteal artery or peroneal nerve injuries.

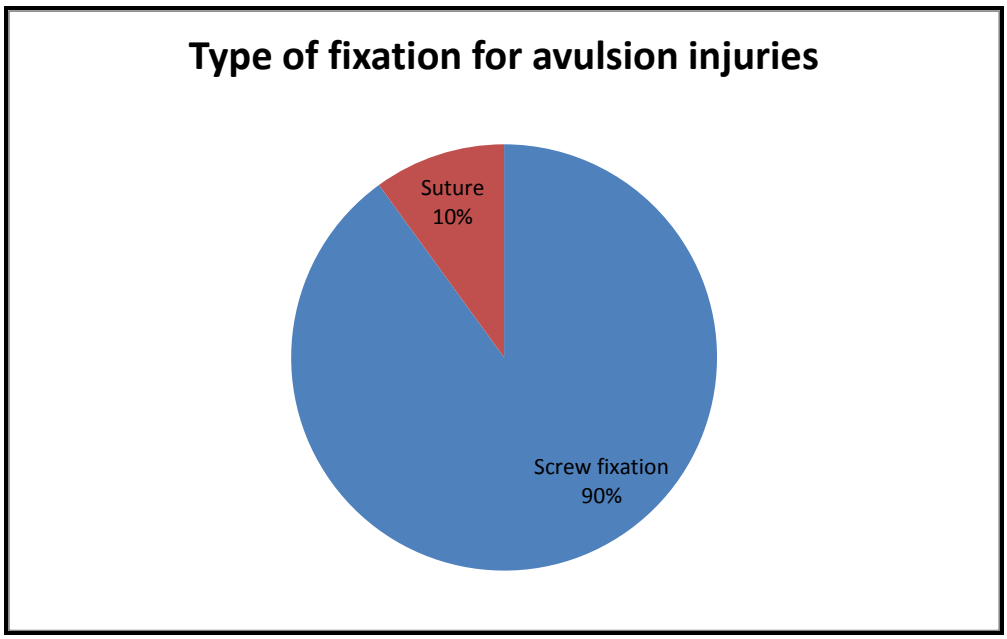


Timing of definitive fixation depends on associated injuries and initial hemodynamic stability and resuscitation. The average number of days before surgery was 14.75 with a range from 10 to 23, D.Sabat et al.[15] in his study reported the average number of days before surgery was 6.2 in the open group [range, 5 to 14 days]. The significant delay in the surgery was the presentation of the patient to us after the time since injury. Fixation of avulsion injuries >3 weeks may be considered as in Bali et al.[3] study, the fixation was preferred in patients who presented >3weeks after injury.

Out of the 10 cases of PCL avulsion, 2 were treated by arthroscopic method and 8 by open method. We preferred open method as it helps in accurate reduction of the fragments to the fracture bed and accurate placement of screw perpendicular to the fracture site. In arthroscopic approach placement of screw perpendicular to the fracture site is difficult, as the guide wire is inserted through the PCL tibia guide. Also accurate reduction of the fragment was difficult with a lift off from the fracture bed postoperatively even on using reduction tools through the posteromedial portal. D.Sabat et al.[15] found no difference between both groups in clinical outcome; radiological healing and knee stability at short term follow up.



The number screws varied according to the size of the fragments. 3 cases needed 2 screws owing to the larger fragment size. Materials used for fixation were 4 mm partially threaded [16mm] cannulated cancellous screws with washer in 9 patients and non-absorbable suture in one patient. There was no reported complication like surgical site infection.

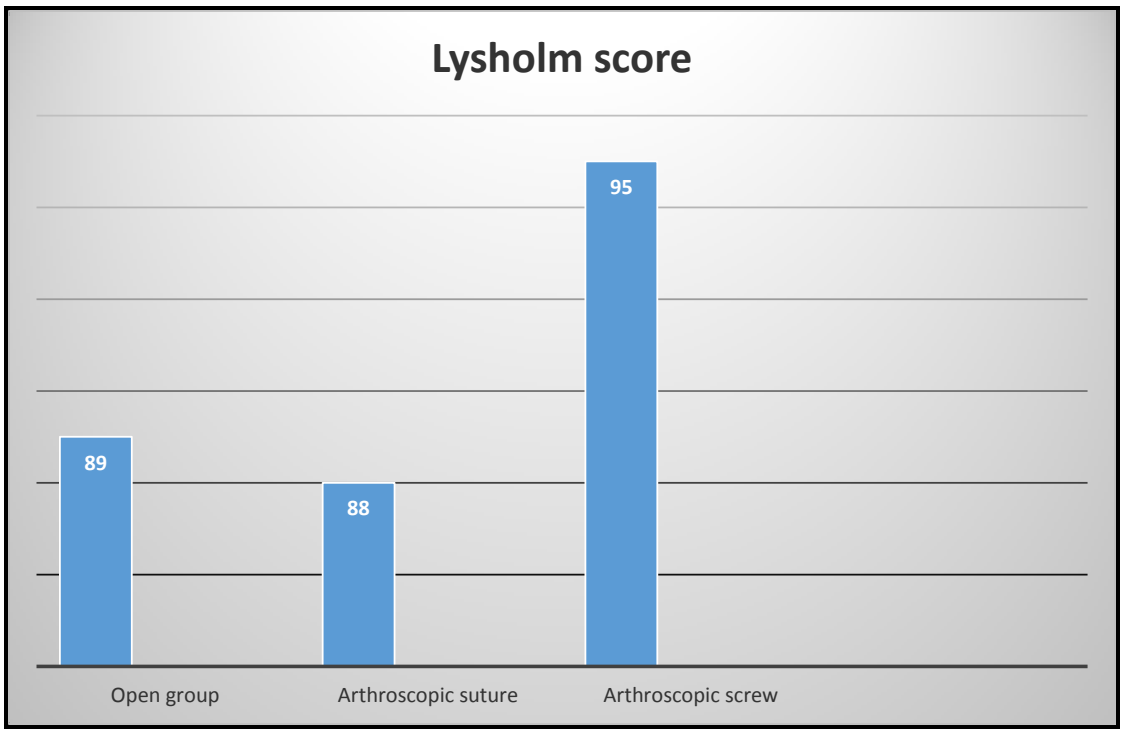


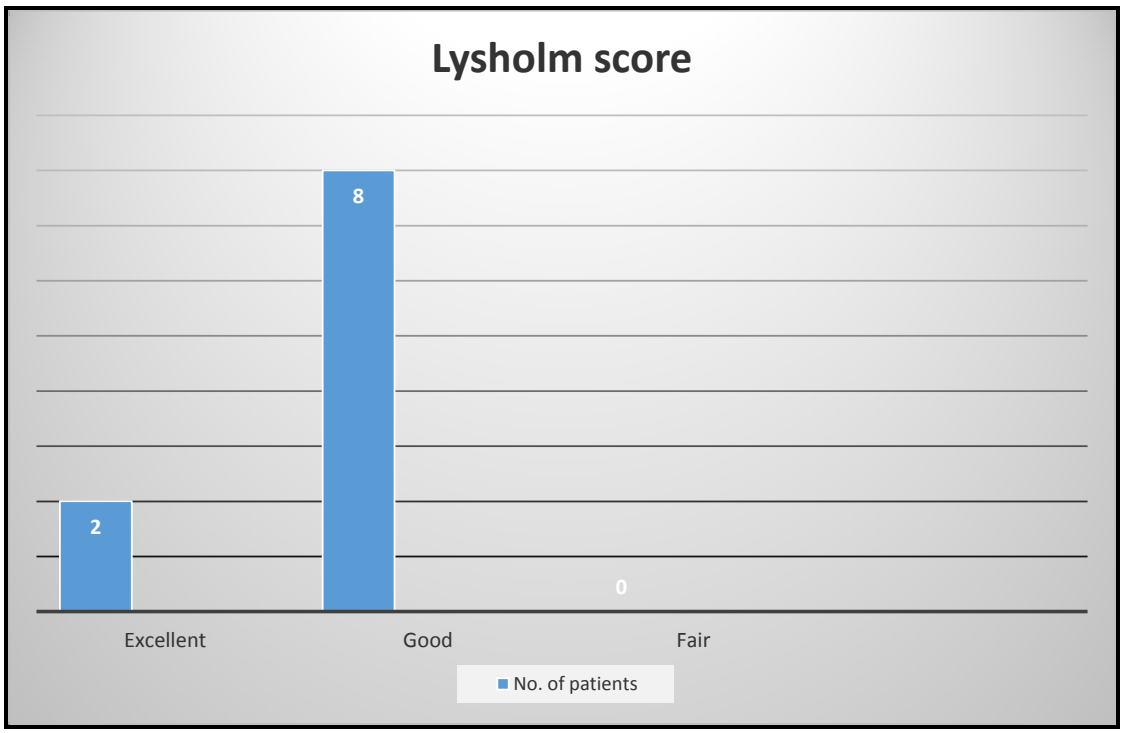
The mean period of follow up was 21.2 months [range, 8 to 43 months], whereas D.Sabat et al.[15] in his study reported an average follow-up of 23.5 months [range, 19 to 57 months].

The mean lysholm score among avulsion injuries was 89.5 [range, 84 to 95]. Two patients had excellent score while 8 patients had good score. The two patients treated by arthroscopic method had a lysholm score of 95 and 88, while the open group had a mean lysholm score of 89. But due to short term nature of the follow-up and small sample size, advantages of the arthroscopic method couldn't be established. D. Sabat et al.[15] in his study reported a mean lysholm of 95.3 in the open group and 94.8 in the arthroscopic group.

The major advantage in the arthroscopic group was to identify any discontinuity in the ligament or injuries to other structures of the knee [midsubstance tear of PCL, meniscal injuries] as some studies have reported occult midsubstance tear in cases with avulsion injuries. But Inoue et al.[36] found that occult midsubstance tear does not affect the stability of the knee postoperatively in patients with PCL avulsion injuries.

The major problem in open method of fixation is knee stiffness. Of the 8 patients in the open group none reported knee stiffness during follow-up and restored full range of flexion. Hence open method can be preferred safely over arthroscopic methods in patients with PCL avulsion injuries.





In our study we report 2 cases of posterior cruciate ligament injuries. Both the cases were associated with meniscal injuries. Both injuries were due to road traffic accidents [collision]. Both the cases

were managed by single bundle reconstruction of the ligament. One patient lost follow up .

Wang et al.[57] reported that both single bundle and double bundle reconstruction produced comparable clinical results in medium-term follow-up.

Bergfeld et al.[58] concluded that double bundle reconstruction does not offer any advantages over single bundle reconstruction. Thus the single bundle technique which is less time consuming and less technically demanding was preferred in our study.

We used single bundle transtibial tunnel technique in both patients. Though Bergfeld et al.[58] reported that tibial inlay technique is superior to the transtibial technique, recent studies [59, 60] have failed to demonstrate any advantages in follow up.

We followed a structured supervised rehabilitation programme, to allow healing after reconstruction. Fanelli et al. [61] reported that PCL reconstruction results in excellent outcome but a slow rehabilitation programme is recommended in contrast to aggressive rehabilitation after ACL reconstruction .

CONCLUSION

PCL bony avulsion constitutes a small subgroup of PCL injuries. It causes pain & knee instability, with limitation of range of motion. Surgical treatment offers satisfactory results with complete functional restoration.

Many fixation techniques have been reported in the literature, open reduction and internal fixation with partially threaded cannulated cancellous screw is reported to be an excellent technique for avulsion fracture of the PCL.

Modified Burks and Schaffer approach is safer and easier. Very minimal dissection is involved and the risk to neurovascular structures is remote.

However, uncertainty exists in the recommendation of optimal treatment for PCL avulsion injuries. A small sample size due to low incidence of these injuries makes it difficult to draw definitive conclusions regarding definite treatment. Long term studies with more subjects will properly define the indication for the different treatment options. Hence multicentric trials can overcome this, to define the best treatment option for avulsion injuries.

CASE ILLUSTRATION - 1

Mr. A, 30 yrs / male

Mode of injury : Road traffic accident, 2wheeler vs 4 wheeler

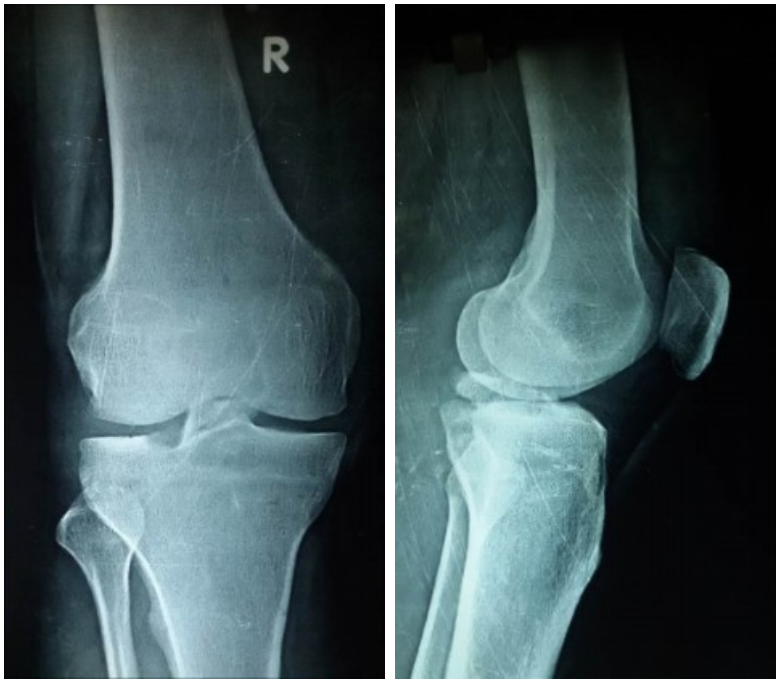
Diagnosis : Posterior cruciate ligament bony avulsion right side

P/D : ORIF with cancellous screw fixation

Final follow up - 43 months

Lysholm score at final follow up - 95

Preop X-ray



Immediate postop X-ray

Clinical picture & X-ray at final follow up

CASE ILLUSTRATION - 2

Mr.B, 30yr / male ,

Mode of injury : Accidental fall from bike

Diagnosis : Posterior cruciate ligament bony avulsion left side

P/D : ORIF with cancellous screw fixation

Final follow up - 10 months

Lysholm score at final follow up - 87

Preop X-ray

Post op X-ray

Final follow up X-ray and clinical picture

CASE ILLUSTRATION -3

Mr. C, 18 yrs male,

Mode of injury : Accidental fall from bike

Diagnosis : Posterior cruciate ligament bony avulsion right side

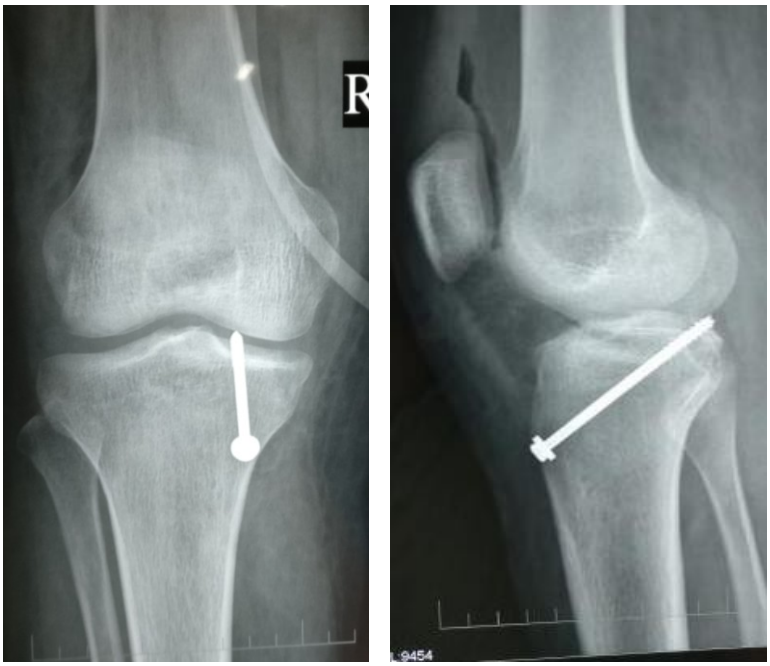
P/D : Arthroscopic cancellous screw fixation

Final follow up - 11 months

Lysholm score at final follow up - 95

Preop X-ray

Post op X-ray



X-ray and clinical picture at final follow up

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PROFOMA

Name :

Age/Sex :

IP no :

Ph. No :

Mode of injury:

Diagnosis :

Associated other ligamentous injuries :

Other associated injuries :

Procedure done :

Follow up :

Final clinical score :

INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE, CHENNAI 600 003

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CERTIFICATE OF APPROVAL

To
Dr.R.Rajkumar
Post Graduate in MS Orthopaedics
Institute of Orthopaedics & Traumatology
Madras Medical College
Chennai 600 003

Dear Dr. R.Rajkumar

The Institutional Ethics Committee has considered your request and approved your study titled **"PROSPECTIVE AND RETROSPECTIVE ANALYSIS OF (PCL) INJURIES AND ITS MANAGEMENT" - NO. 22012017 (II).**

The following members of Ethics Committee were present in the meeting hold on **19.01.2017** conducted at Madras Medical College, Chennai 3

1.Dr.C.Rajendran, MD.,	:Chairperson
2.Dr.M.K.Muralidharan,MS.,M.Ch.,Dean, MMC,Ch-3	:Deputy Chairperson
3.Prof.Sudha Seshayyan,MD., Vice Principal,MMC,Ch-3	: Member Secretary
4.Prof.B.Vasanthi,MD., Prof.of Pharmacology.,MMC,Ch-3	: Member
5.Prof.A.Rajendran,MS, Prof. of Surgery,MMC,Ch-3	: Member
6.Prof.N.Gopalakrishnan,MD,Director,Inst.of Nephrology,MMC,Ch	: Member
7.Prof.Baby Vasumathi,MD.,Director, Inst. of O & G	: Member
8.Prof.K.Ramadevi,MD.,Director,Inst.of Bio-Che,MMC,Ch-3	: Member
9.Prof.R.Padmavathy, MD, Director,Inst.of Pathology,MMC,Ch-3	: Member
10.Prof.S.Mayilvahanan,MD,Director, Inst. of Int.Med,MMC, Ch-3	: Member
11.Tmt.J.Rajalakshmi, JAO,MMC, Ch-3	: Lay Person
12.Thiru S.Govindasamy, BA.,BL,High Court,Chennai	: Lawyer
13.Tmt.Arnold Saulina, MA.,MSW.,	:Social Scientist

We approve the proposal to be conducted in its presented form.

The Institutional Ethics Committee expects to be informed about the progress of the study and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

Member Secretary – Ethics Committee

MEMBER SECRETARY
INSTITUTIONAL ETHICS COMMITTEE
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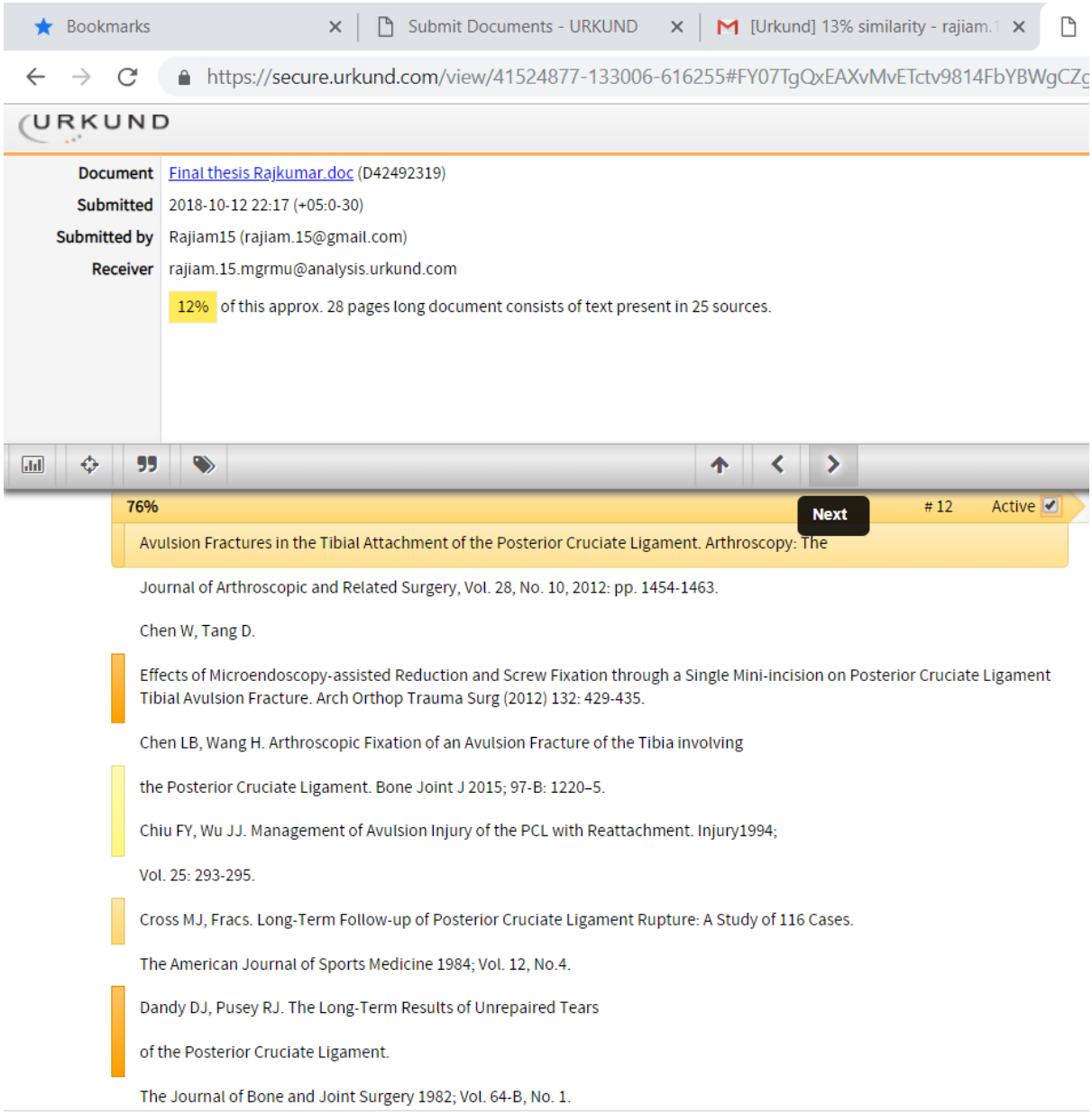
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PLAGIARISM CERTIFICATE

This is to certify that this dissertation work titled **"PROSPECTIVE AND RETROSPECTIVE ANALYSIS OF POSTERIOR CRUCIATE LIGAMENT INJURIES AND ITS MANAGEMENT"** of the candidate Dr.R.RAJKUMAR with Registration Number 221612009 for the award of M.S., DEGREE in the branch of BRANCH-II (ORTHOPAEDIC SURGERY). I personally verified the urkund.com website for the purpose of plagiarism Check. I found that the uploaded thesis file contains from introduction to conclusion pages and result shows 12% of plagiarism in the dissertation.

Guide & Supervisor sign with Seal

<u>ஆராய்ச்சி தகவல்தாள்</u>

ஆராய்ச்சி தலைப்பு
கடந்தகால மற்றும் வருங்கால மூட்டின் பின்பக்க தசைநார் காயங்கள் வைத்திய முறையும் மற்றும் அதன் விளைவுகள் பற்றிய ஆய்வு

பெயர்	:	தேதி	:
வயது	:	உள் நோயாளி எண்	:
பால்	:	ஆராய்ச்சி சேர்க்கை எண்	:

ராஜீவ் காந்தி அரசு பொது மருத்துவமனைக்கு வரும் நோயாளிகளை கொண்டு ஒரு ஆய்வு நடத்துகிறோம். அதற்கு உங்களின் பரிசோதனை முடிவுகள் எங்களுக்கு உதவியாக இருக்கும்.

இந்த ஆய்வில் தங்களை பங்கேற்க அழைக்கிறோம். இந்த தகவல் அறிக்கையில் கூறப்பட்டிருக்கும் தகவல்கள் தாங்கள் இந்த ஆய்வில் பங்கேற்கலாமா வேண்டாமா என்பதை முடிவு செய்ய உதவியாக இருக்கும். இந்த படிவத்தில் உள்ள தகவல்கள் பற்றி உள்ள சந்தேகங்களை நீங்கள் தயங்காமல் கேட்கலாம்.

நீங்கள் இந்த ஆராய்ச்சியில் சேர்த்துக்கொள்ளப்பட்டால் முடிவுகளை அல்லது கருத்துக்களை வெளியிடும் போதோ அல்லது ஆராய்ச்சியின் போதோ தங்களது பெயரையோ அல்லது விவரங்களையோ வெளியிடமாட்டோம் என்பதையும் தெரிவித்துக் கொள்கிறோம்.

இந்த ஆராய்ச்சியில் பங்கேற்பது தங்களுடைய விருப்பத்தின் பேரில்தான் இருக்கிறது. மேலும் நீங்கள் எந்த நேரமும் இந்த ஆராய்ச்சியில் இருந்து பின் வாங்கலாம் என்பதையும் தெரிவித்துக்கொள்கிறோம்.

இந்த சிறப்புப் பரிசோதனைகளின் முடிவுகளை ஆராய்ச்சியின் போது அல்லது ஆராய்ச்சியின் முடிவில் தங்களுக்கு அறிவிப்போம் என்பதையும் தெரிவித்துக் கொள்கிறோம்.

ஆய்வாளரின் கையொப்பம் **பங்கேற்பாளர் கையொப்பம்**

தேதி

MASTER CHART											
Case no	Age (yrs)	Sex	IP No	Side	Mechanism of injury	Associated injuries	Interval between injury & surgery	Method of fixation	Follow up (months)	Lysholm Knee score	Complications
1.	38	Male	58998	Left	Accidental fall	Nil	11	ORIF with cancellous screw	39	85	Nil
2.	32	Male	12104	Left	RTA	Nil	16	ORIF with cancellous screw	28	90	Nil
3.	30	Male	50055	Right	RTA	Nil	13	ORIF with cancellous screw	43	95	Nil
4.	30	Male	72632	Left	Accidental fall	Nil	15	ORIF with cancellous screw	10	87	Nil
5.	18	Male	67683	Right	Accidental fall	Nil	18	Arthroscopic screw fixation	11	95	Nil
6.	21	Male	97772	Right	RTA	Bilateral # both bone forearm	14	ORIF with cancellous screw	9	94	Nil
7.	42	Male	109256	Right	Dashboard injury	Nil	10	ORIF with cancellous screw	8	87	Nil
8.	40	Male	103712	Left	RTA	Nil	23	Arthroscopic suture fixation	26	88	Nil

MASTER CHART											
Case no	Age (yrs)	Sex	IP No	Side	Mechanism of injury	Associated injuries	Interval between injury & surgery	Method of fixation	Follow up (months)	Lysholm Knee score	Complications
9.	32	Male	23671	Right	RTA	Nil	12	ORIF with cancellous screw	18	90	NIl
10.	26	Male	121669	Right	RTA	#Both bone leg	13	ORIF with cancellous screw	18	87	Nil
11.	25	Male	10335	Right	RTA	Nil	90	Arthroscopic ligament reconstruction	14	90	Nil
12.	30	Male	90702	Right	RTA	Nil	55	Arthroscopic ligament reconstruction	Pt. Expired		